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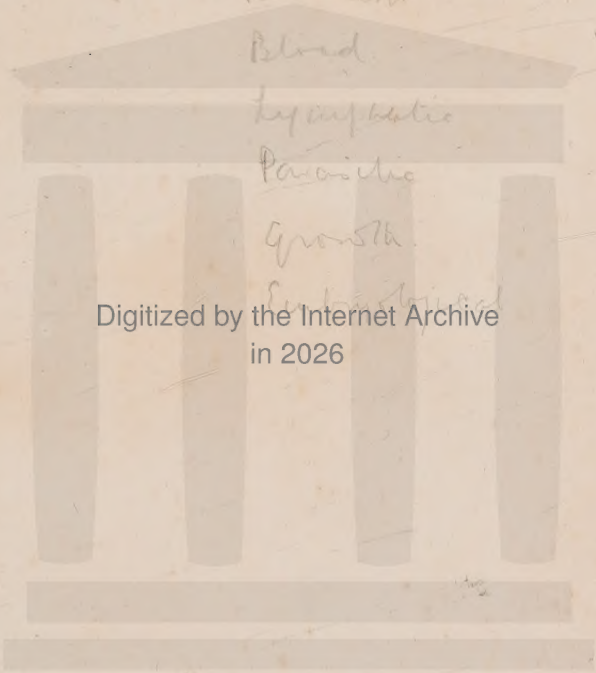

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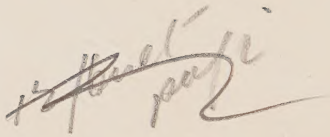

FRACTURES
COMPOUND FRACTURES
DISLOCATIONS

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MCMXIX.

FRACTURES
COMPOUND FRACTURES
DISLOCATIONS

AND THEIR TREATMENT

WITH A SECTION ON
AMPUTATIONS AND ARTIFICIAL LIMBS

BY

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PREFACE

The writer has endeavoured to give in a book of moderate size the facts concerning fractures and dislocations and their treatment, which are likely to be called for by students and practitioners, even when dealing with unusual or difficult cases.

When there is diversity of opinion, emphasized perhaps by the war, as to the merits of treating fractures by splints, extension, massage, or operation, students require guidance in the selection of methods of treatment. In the section on fractures in general the various systems are discussed, while under the more important individual fractures the most suitable forms of treatment, including splints wherever applicable, are described and figured in detail, whereby it is hoped the subject will be rendered clear.

Compound fractures are fully dealt with, and the lessons of the war as to the best methods of preventing sepsis and loss of life or limb are incorporated. These methods have been employed and taught by Sir William Macewen as best for the treatment of compound fractures in civil life for many years past, and the writer has also followed his teaching on many points, such as the operative treatment for transverse fracture of the patella, which is now generally adopted.

The war has unfortunately brought the subject of amputation for severe compound fracture, re-amputation, and the fitting of suitable artificial limbs into prominence. Endeavour has been made to give briefly the conclusions arrived at in the Princess Louise Scottish Hospital for

Limbless Sailors and Soldiers, Erskine, as to which amputations generally yield the most useful stumps, and the types of temporary and 'permanent' limbs most suitable for use with these. Such opinions are of course subject to revision, and it is gratifying to record that improvement in construction and fitting of artificial limbs has been continuous since the opening of that Institution, due, in considerable measure, to the work of the Erskine Research Laboratory.

The section on the Healing of Fractures is the outcome of original experimental research on animals undertaken by the writer several years ago. He is indebted to Dr. J. R. Shaw, D.P.H., now assistant M.O.H., Cheshire County, for assistance in preparing and examining large numbers of sections of healing bones at various stages.

The plates are almost entirely made from photographs in a collection begun by Sir William Macewen in the earliest days of dry-plate photography and continued by the writer. One plate is taken from Sir William Macewen's book on the Growth of Bone, and several on provisional limbs are from a pamphlet issued by the Erskine Research Laboratory.

The writer has consulted the standard works on fractures and dislocations, and has availed himself of information given in many articles, and by friends, in addition to personal observation and experience regarding work done and results obtained in Naval and Military Hospitals in France and at home. He has also much pleasure in acknowledging his indebtedness to his brother, Capt. William Macewen, D.P.H., O.B.E., who, although on active service abroad, contributed many helpful suggestions and criticisms; to three medical students in particular—Miss Nora G. Henry, M.A., for executing many of the line diagrams, and Misses J. Grizel Service, M.A., and Edith I. Thornley for critical revision of the text,—and to the Staff at Erskine.

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FRACTURES IN GENERAL

Fracture, surgically, is the sudden solution of continuity of a bone or cartilage.

A *complete fracture* is one in which the line of fracture completely traverses the bone, which is thereby completely separated into fragments : an *incomplete* fracture is one in which there is a partial separation of the bone.

A *simple fracture* is one in which the bone is broken at only one point. A *comminuted* fracture is one in which the bone is broken at more than one point, and in which, in consequence, the bone is divided into more than two fragments.

A *compound fracture* is one in which there exists also an external wound communicating with the bone at the point of fracture. A compound fracture may be partial, complete, or comminuted.

A *complicated fracture* is one in which, in addition to the fracture, there is a lesion of some other structure, such as a vessel or nerve.

An *impacted fracture* is one in which the fragments are driven into one another.

A *fissured fracture* is a crack or split, and is incomplete in itself, although it may extend from a complete fracture. It is most frequently met with in the skull.

A *depressed fracture* is one in which a portion of the bone is driven in and lies below the general surface level. It also occurs frequently in the skull.

A *sprain fracture* is one in which the surface layers of

a bone are pulled off by the tendon or ligament inserted into them.

A *greenstick fracture* is one in which the fracture is incomplete, part of the bone bending only, and not breaking, while a longitudinal split frequently co-exists. This form occurs generally in early life.

A *spontaneous fracture* is one produced by a minimum of violence or exertion. A *pathological* fracture is one where the bone is previously weakened or partially destroyed by disease.

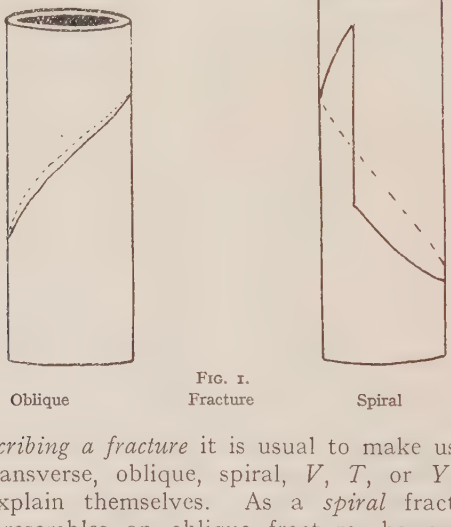


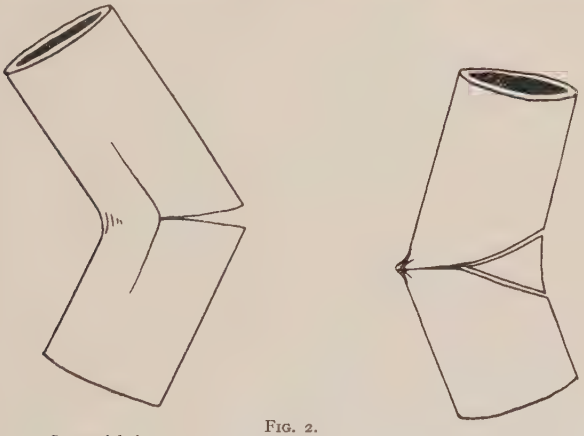
FIG. 1.
Fracture

In *describing a fracture* it is usual to make use of the terms transverse, oblique, spiral, *V*, *T*, or *Y* shaped, which explain themselves. As a *spiral* fracture frequently resembles an oblique fracture, however, it is well to remember that in a spiral fracture the sharp pointed extremities of the broken fragments lie on the same aspect of the bone, whereas in an oblique fracture they lie upon opposite sides.

There are **two main determining causes of fracture.** (1) *Violence.* This may be direct or indirect. *Direct*, where the bone breaks at the point of impact of the

blow; *indirect*, where it breaks at a distance as the result of a transmitted force. Most of the very common fractures, such as Pott's or Colles', are caused by indirect violence, and even short bones may be fractured by indirect violence as in the vertebrae.

A third form of violence is sometimes described under the term counter stroke or *contre coup*, where, for example, a person falling on the back of the head sustains



Greenstick fracture

Triangular portion of bone set free on side of concavity

FIG. 2.

a fracture of the orbital plate of the frontal. This is not a common cause, and the example given is practically the only one which occurs.

(2) *Muscular action.* The most common example of this form is transverse fracture of the patella, due to exaggerated action of the quadriceps. The olecranon and other apophyses and tuberosities are much less frequently fractured by muscular action, while, of the long bones, the humerus has occasionally been fractured in this manner.

Mechanism of production of Fractures. When *violence is applied at right angles* to the shaft of a bone,

the shaft bends, and in so doing its fibres on the convexity of the curve tend to be torn apart, while those on the concavity tend to be compressed. If the fracturing force be sufficient to produce a partial separation, a *greenstick fracture* results, the fracture being situated on the side of the convexity of the curve produced by the bending force, while bending and compression occur on the side of the concavity. If, however, the force be sufficient to produce a complete fracture, the tendency is for two diverging cracks to start together from the convexity and run across to the concavity, whereby a triangular portion of bone is set free, lying on the side of the concavity, with its apex directed toward the gap in the bone from which it came. Should one of the diverging cracks not develop, an *oblique fracture* is produced by the bending force, and it sometimes happens that even a *transverse fracture* may be produced by such a force, there being generally, however, two small diverging cracks at the convexity end of the fracture.

When violence takes the form of *torsion*, a *spiral fracture* generally results. The foot projecting at right angles from the leg is often the medium through which torsion is applied, and thus it happens that spiral fractures are most frequently seen in the tibia, and then in the femur, and much less often in the humerus, as torsion applied from the bent elbow tends to produce dislocation of the head of the humerus instead of fracture of the shaft. As torsion is generally combined with flexion a fragment of bone is often detached, but in this case it is quadrilateral as a rule instead of triangular, as occurs when flexion alone is the cause of fracture.

Separation of an epiphysis is a form of fracture which occurs generally between the ages of twelve and eighteen. It may be produced by direct violence or by a wrenching action at the joint. In some cases the attachment of the periosteum limits displacement, but in others the displacement is very great. Reposition is often difficult and may necessitate operation. The joint movements

may be impaired and growth of the bone arrested, particularly when the epiphysis affected is specially concerned in growth as that at the upper end of the shaft of the humerus.

A considerable number of **conditions predispose to fracture.** *Senile atrophy* may lead to spontaneous fracture, or one due to slight indirect violence; *fragilitas ossium* may cause fracture of the humerus, for example, when the patient is turning in bed. *Diabetes* causes brittleness of bones in some cases; *rickets*, during the active stage of the disease in early youth may be a possible cause; *syphilis* in a few cases; *tubercle* occasionally, as when it affects the ribs, and *osteomyelitis* particularly when it affects the shafts of long bones in adults. *Tumours*, such as sarcoma and carcinoma, and also cysts of bone may cause spontaneous fracture, and the erosion of vertebrae or sternum by *aneurism* may have a similar result. Severe *nervous diseases* such as locomotor ataxia or syringomyelia may also predispose to fracture.

Objective Signs.

Certain signs generally exist where there is a fracture, by means of which we are aided in the recognition and diagnosis. All of these signs are not necessarily present in the case of a particular fracture, nor are they of equal importance.

Deformity is probably the most constant sign, but it is not necessarily the most obvious, as in the case of some incomplete or impacted fractures. Deformity may be due to the fracturing force, to muscular action, or to weight of the limb. The displacement caused generally gives rise to shortening, due either to overriding of the fragments upon one another, or to impaction of one fragment into the other. Angular deformity is also common, often associated with shortening, or occurring in incomplete and greenstick fractures. Pure lateral deformity only occurs in the case of a transverse fracture through a broad surface, such as obtains near

a joint. In other cases it is associated with shortening or angular deformity. Rotatory deformity generally occurs round the long axis of the limb, and is due to torsion, violence, or weight of the limb in most cases.

Separation of the fragments in the longitudinal axis of the limb is generally only seen in such cases as fracture of the patella or olecranon where the fragments are acted on by attached muscles.

Where a fracture is not seen for some time after it has occurred deformity may be masked to a considerable extent by *swelling*, but shortening can generally be revealed by comparative measurements between given bony prominences.

Preternatural mobility is a very definite sign when it can be elicited, but it is absent where there is impaction, and also generally in fractures of the skull and pelvis.

Crepitus is the term applied to the feeling or sound of grating when the broken ends of the bone are rubbed against one another. Osseous crepitus must be carefully distinguished from crepitus due to inflammation of synoviae surgical emphysema, or the breaking up of blood clot, and, on the other hand, it must be remembered that crepitus is absent where there is absence of coaptation of the fragments, due, for example, to interposition of muscle or blood clot, and when the fragments are impacted.

Subjective Symptoms.

There are also a number of subjective symptoms. *Inability to use the limb* is a general symptom, but it is by no means absolute. Thus numerous cases are on record of a patient being able to walk although the tibia was fractured, and the writer has seen cases of fractured pelvis and of pathological fracture of the neck of the femur where the patient could walk with comparative ease.

Pain is generally constant and localised; *tenderness* on pressure marked, and pain from pressing the broken ends together equally marked.

The **diagnosis** of a fracture is generally more easily made if seen immediately after its occurrence. There is then little or no swelling, and the deformity is therefore obvious, or can be made out by running the fingers gently along the affected bone. Muscular resistance is generally less; indeed a certain degree of shock may exist, so that preternatural mobility is easily elicited, and reposition, if necessary, effected. In some cases, however, muscular spasm immediately supervenes, due, probably, to injury to the muscles, or nerves supplying them. In such cases, or where swelling or rigidity makes diagnosis difficult, it may be necessary to give an anaesthetic, and then, having diagnosed the condition, the fracture may be set.

Skiagraphs are of great use in diagnosing fractures and indicating the displacement and amount of damage of the bones, and their use with these objects is steadily growing. Their use, however, should not be confined to diagnosis. They should be employed to show whether setting has been successful, and when possible, it is wise to have a skiagraph taken after the fracture has been set and put up, to make sure that apposition is satisfactory. As a rule two skiagraphs should be taken in planes at right angles to one another, as a single skiagraph may be very misleading. A good deal of experience is necessary in interpreting skiagraphs. They frequently tend to exaggerate deformity. Callus, at least in the earlier stages, is transparent to X-rays, and almost invisible, and so is cartilage. The epiphyseal ends of long bones of children are therefore invisible, while the ossific centres appear as detached fragments of bone, and may easily lead to errors in diagnosis.

It is generally best to show skiagraphs to the patient, explain them to him, and, if the position be not satisfactory, tell him so, and indicate what further treatment may be required to improve matters, and get his decision. In this way legal trouble may often be obviated.

Treatment in General.

Preliminary.

When it is necessary to *remove the patient* from the scene of the accident, care must be taken to prevent aggravation of the injury. Speaking generally, extension and counter-extension should be applied by assistants, who should be instructed to take gentle but firm hold of the limb with the whole hand, and not with the finger-tips, so as to prevent wobbling of the fragments and consequent suffering. While extension and counter-extension are thus made, the operator fixes the broken limb by the application of temporary splints composed of walking sticks, cardboard, etc., held in position by handkerchiefs or other ties. The application of extension and counter-extension is not invariably safe and harmless. In the case of a *compound fracture* where the injured bone is projecting through the skin, such treatment tends to draw the protruding bone back into its place, carrying septic matter along with it. Such fractures are best kept in the position in which they are found until they can be properly treated, while an antiseptic dressing is applied over the projecting bone, which should not be replaced at this stage.

Rings and constricting bands should be removed at once before the swelling becomes so great as to prevent their easy removal, when they may cause gangrene, and it is generally well on admission to hospital to make sure that a tourniquet has not been applied, particularly if the fracture be compound, in some effort at first aid.

Care should be exercised in removing the clothing not to inflict further damage. It is generally best to get the sound limb out first, but even with this aid it is sometimes necessary to slit the garments along a seam in order to facilitate removal.

A *fracture bed* should be narrow; sufficiently long to permit of extension or other apparatus being applied, and it should be firm. A mattress on the top of boards

is best; a spring mattress is unsuitable. In the case of fractures of the pelvis and lower limb it is a great convenience to have the mattress in four pieces; an upper for the head, shoulders, and trunk; a lower for the legs, and two half pieces for the pelvis, the latter being covered with a draw sheet. When it is necessary to introduce a bedpan one of these half pieces is withdrawn entirely, and the other nearly so; the drawsheet is depressed, and the bedpan introduced without disturbing the fracture.

A special high narrow bedstead with mattress replaced by several detachable canvas slings on top of which are placed small sectional mattresses and which is readily adjustable for all forms of extension has been issued by the War Office and is made by Whitfield, Birmingham.

Actual.

It is necessary at this stage to consider the objects we have in view in treating fractures, and the means which may be employed to attain these ends. The ideal would be a rapid restoration of alignment, functions and power.

External Splints. If we can keep the limb absolutely at rest, so that the broken ends will not be disturbed, and these ends are kept in accurate apposition, while the axis of the limb is maintained, we may reasonably expect satisfactory union. This is the aim of the external splint method as usually applied, and if the setting has been correct, a good result so far as the bone is concerned is generally obtained. But it must be recognised that this result is obtained at the expense of the muscles and joints. The muscles atrophy from pressure, disuse, and diminished blood supply, while the joints become stiff from long immobility, with the result that, although the bone may be satisfactorily healed, the limb has had its function seriously impaired, necessitating in many cases weeks of subsequent treatment before the limb is restored to usefulness.

Further, it is now recognised that many fractures have

but little tendency to recurrence of displacement, once they have been reduced, while others maintain their position from the first. It is questionable how far the application of splints in the orthodox method is justified in such cases, as they would appear likely to do well without splints, if care be taken, while the use of the splints is open to the objections just stated. On the other hand, in many cases where reduction of displacement is difficult to maintain, splints do not sufficiently maintain a corrected position. Treatment by splints applied externally has been the practice hitherto, and if it falls into disuse, the process is likely to be gradual. A careful account is therefore given later of the methods employed in general, and again in particular under each fracture which can be so treated.

Extension. A second method, which has often been used in conjunction with splints—not always with advantage—is that of extension. Extension is probably gradually displacing the use of external splints for many fractures, and its advantages have been largely recognised and utilised during the present war.

Extension is particularly useful in *overcoming muscular spasm*, which is often present, and which in many cases is the cause of displacement. In extension, which is applied in the long axis of the limb, the muscles are stretched, and spasm prevented. In employing certain forms of extension we commence treatment with what is really an overstretching of the muscles, which (as in the case of the sphincter ani), inhibits action for several days. But the advantages of extension do not end with allay of muscle spasm. As the muscles are stretched the bone is also pulled upon, so that *overlapping is undone*; indeed, in some cases a short gap is produced between the ends of the bone when very heavy extension is applied at first, and this fact, combined with the tension placed upon all other structures, makes it *unlikely that tissue will remain between the fragments*, unless it be entirely detached. Still further, some hold, and probably with

reason, that the full tension *forces all structures to assume and maintain their normal positions* and bone has to behave likewise. *Massage and passive movement can be carried out with ease* from the beginning without interfering with the extension or at most slightly reducing the weight, and compound fractures similarly can be dressed.

Since extension has so much to commend it, and its use is rapidly increasing, a careful description of its application in general, and in particular fractures is also given.

A description of the methods of treatment in use at present would not be complete without reference to two other methods which, in some respects, are the antithesis of one another. These are the treatment by massage, as advocated by the late Professor Lucas Championniere, and that by open operation.

Massage. *Championniere* insisted upon the importance of preserving the utility of a limb as a first consideration. He pointed out that pain often caused muscle spasm and hence brought about deformity ; that if pain could be prevented, spasm and deformity would be minimised, and, in any case, that good function was of much greater importance than mere perfection of alignment. He showed at the Surgical Congress in Brussels in 1911, skiagraphs of many cases in which there was imperfect alignment, where, nevertheless, function had been perfectly restored. The method is particularly applicable to those forms of fracture in which displacement either does not occur, or in which, after reduction, the parts tend to remain in position. Colles' fracture is perhaps the most suitable one for this treatment, to which may be added incomplete and subperiosteal fractures, impacted fractures in good position, and fractures near joints where the fractured surfaces are broad.

The *massage consists* of gentle monotonous rhythmic stroking of the affected limb in an upward direction. This is continued for perhaps ten minutes, at the rate of some twenty strokes per minute and has the effect of soothing the patient and relaxing the muscle spasm. The

fracture can then be examined while the stroking is continued, and even reduction of slight displacement may be possible under its influence, the assistance of an anaesthetic being required in more difficult cases. The stroking is then continued, a sitting generally lasting for about twenty minutes, after which the limb may be supported by a sling or splint. Similar treatment is given daily, passive movement of the joints being carried out from the beginning, and active movement encouraged sometimes from the beginning, as in Colles' fracture, and in other cases after the first few days.

It will be noted that the massage here described is not what is generally understood by that term. Championniere was particularly emphatic that, to be successful with his method, no pain must be caused. If pain be produced, muscle spasm is excited, and the treatment is spoiled.

Students must not conclude that this is an easy way of treating fractures. It requires judgment in the selection of suitable cases, and much care and experience, together with the daily expenditure of a considerable amount of time if good results are to be obtained, and it must also be remembered that the results, as revealed by skiagraphs, are often far from aesthetic.

Much has been done of late in the **operative treatment of fractures** whereby perfect reposition and alignment are obtained, while the parts are maintained in position by means of metal plates, screws or wires. Some surgeons treat many of their fractures by operative methods, while others, and probably the majority, confine this practice to the treatment of cases which cannot be satisfactorily dealt with otherwise.

While the reposition of the fragments is sometimes easy, it is often difficult, and this is particularly the case when, owing to delay in treatment, the bones have become partially fixed in faulty position and the muscles have become contracted owing to shortening of the limb. Many instruments have been devised to facilitate the manipulation of fractures, and long bone levers, such as

those of Lane, and large forceps or tongs to hold the parts in position while they are being fixed, are of great assistance.

In many cases it will be found advisable, after the site of fracture has been exposed, to *increase the deformity* by bending the limb at the point of fracture to a right angle, with a view to seeing the broken ends, removing all soft tissue intervening, and possibly small fragments of bone. The operator can then determine how best the ends may be made to fit one another, and fixed after they are fitted. If, while the limb is in this position, the broken ends are coapted, and then pressure is applied to force the limb straight, very forcible extension is thereby applied to the limb and marked shortening may be overcome.

Where a fracture is comminuted, and particularly where portions of shaft are loose or detached, reposition may be very difficult, and abundant assistance is generally essential to hold the bone levers in position and to apply strong extension, counter-extension, and rotation as directed by the operator. Once satisfactory reposition has been achieved, the fragments should, if possible, be *clamped in position* by the tongs or similar instrument, and the operator should inspect the limb to satisfy himself that the alignment is good before proceeding to fix the fragments.

In fixing the shaft of a long bone, a *plate* or plates, are generally best, and these plates should have at least two apertures for screw nails at each end. If this point be not attended to the plate tends to slew with some movement of the limb, and angular deformity results. The plate should be of suitable length and strength for the bone to be united, and care should be exercised in the choice of position in which the plate is to be fixed. In the case of the tibia, for example, one is tempted to apply the plate to the subcutaneous surface as being broad and easily got at, and, if the fracture be a very difficult one this may be justifiable. But plates placed subcutane-

ously are particularly apt to cause subsequent trouble, and hence a position on the lateral surface, under cover of the muscles, is preferable.

Much of the success in plating depends upon the type of plate and screw used. Flat plates are often used and fixed in position by short wood screws, the thread being cut right up to the head of the screw, and the screw obtaining its hold by being driven through the hard shaft down to the medulla. Such an arrangement is very apt to work loose in a short time, as the wood screw does not cut an efficient thread in the bone, and the bone round it rapidly absorbs under pressure of the screw. Such looseness tends to permit movement of the fragments, and by damaging the tissues leads to exudation of serum and possibly to haemorrhage and even sepsis, necessitating removal of the plate. Plates, instead of being flat, should be curved in section. They then sit more closely to the bone, and the edges may assist in catching and holding the bone. Not only should there always be at least two holes at each end of the plate, but it is often of advantage if these holes are not in line with one another, as is usually the case. Still further rigidity may be obtained if the two sets of screws are sent in opposite oblique directions into the bone, each directed toward point of fraction instead of vertically.

The *screws* employed should have metal threads instead of wood threads, as the former, particularly if self tapping as in Sherman's type, cut a real thread in the bone, and so hold much more securely, while the bone does not tend to absorb nearly so readily, owing to there being comparatively little pressure exerted on it by the screw.

It has also been recommended, with a view to obtaining lasting rigidity, that holes should be bored through the *whole thickness of the shaft*, perforating the hard bone on either side, and that split pins be inserted through the plate and then through these holes, and their ends separated and turned out on the opposite side of the bone. It is best to make the ends of the split pin lie up and

down instead of across the shaft. Or two plates may be used ; one on either side of the bone, connected by short bolts and nuts.

Plates and screws of *sterile bone* or other absorbable material have been used successfully.

Many instruments have been devised to assist plating, but a good drill is essential, together with a bit which will drill a hole of exactly the right size for tapping with the screw chosen. A screw-driver which holds the screw by means of a clamp like a crayon-holder is also a great assistance.

In many instances a single plate is sufficient, but two plates, or a plate and a wire of silver or aluminium bronze may be required. For placing a thick wire round a bone an instrument like a large hernia needle with a blunt point and large eye is very useful. The ends of the wire are crossed, after the instrument has been withdrawn and unthreaded, and twisted together, the wire becoming tighter and gripping the fragments firmly. Care must be taken, however, not to overtwist and break the wire.

Fractures of epiphyseal ends of bones may be similarly fixed, or pins or long screws may be used to hold the fragments in position. In some cases, as for example in fracture of the neck of the femur, a long steel pin may be driven through the skin to traverse the great trochanter and neck, and engage the head.

In *transverse fracture of the patella* operation is generally necessary to remove the intervening aponeurosis, and while the fragments may be held in position by wires introduced through holes bored in the fragments, it is generally sufficient to use stout catgut.

The plate method offers particular advantages in the treatment of **compound fractures**, as it does away with the troublesome external splint, and much of the pain incident upon dressing and consequent movement of the bone. As a compound fracture generally calls for operative treatment in any case, the beginner is apt to consider such a case as most suitable for a first attempt at plating. To obtain successful results in such cases,

however, requires both skill and experience. While they can be obtained even when the patient is first seen by the surgeon days after the accident, and the parts are septic, a local osteomyelitis may easily be set up in the ends of the bone, which die, and there is consequently no attempt at union. The lines upon which treatment in such cases should be carried out are discussed under the treatment of compound fractures (*q.v.*).

After operation the limb should be kept at rest for a week supported by sandpillows if necessary, and then gentle massage and passive movement should be begun. In fractures of the upper limb the patient may attempt to move the limb as soon as he feels disposed, while in those of the lower limb, if the plating has been thoroughly satisfactory, he may be allowed to get up on crutches after about a month, with a light removable plaster casing on the affected limb, and a boot with a high sole on the sound foot. The crutches may be replaced by sticks after about six weeks.

Apposition and alignment are generally perfect after a successful plating operation, and the callus firm and not excessive in amount. Occasionally, however, union is rather slow, and, if the plate yields, bending may occur. Sometimes also, particularly where the plate is subcutaneous or has become loose, it may give rise to subsequent trouble, perhaps a year or so after its insertion, and necessitate removal by operation.

In cases where the plates cannot be relied upon to keep the parts absolutely rigidly in apposition, it is generally well to put the limb up in extension after operation, and to maintain the extension until the union has become perfectly firm.

The Treatment in General of Fractures by Means of External Splints.

In all cases where a splint or extension strapping is to be applied, the limb should first be washed with soap and water, shaved, dried, rubbed with turpentine to remove

fatty matter, the turpentine being carefully dried off, and then well washed with spirit. When a splint is to be applied the limb should lastly be dusted with boracic powder.

Before applying the splint it is necessary to satisfy oneself that the broken ends of the bone are in good apposition, and that the alignment of the limb is correct. If they be not so, it is necessary to "*set*" the fracture. All fractures, however, do not require setting. In some cases there is no obvious displacement, as in transverse fracture of the tibia alone; in others the displacement is slight and may be corrected by the subsequent treatment. Fractures of the skull, ribs, scapula and ilium seldom require setting. In fractures of the skull and ilium the complications are often of more importance than the fracture, and occasionally it may happen that, even where there is displacement, its correction must be delayed on account of more clamant conditions which co-exist.

Setting is performed, under an anaesthetic if necessary, by applying firm *extension and counter-extension*, and endeavouring to replace the displaced bony surfaces accurately in position, while seeing that the alignment of the limb is restored. In some cases this is easy, but in others, owing to firm impaction, the interposition of muscle or other structures between the fragments, muscular shortening, or simple muscular action, it is very difficult. It is here that a knowledge of the various types of fractures and their tendency to displacement, as given later on, is of great assistance. When one knows, for example, that in a fracture of the upper third of the femur the upper fragment is flexed, it follows that replacement will most readily be effected if the lower fragment be also put in this position while attempting reduction.

In the attempt to get the limb straight a greenstick fracture may be converted into a complete fracture. The force required to break down an impaction is often very

considerable, and where a fracture is impacted and in good position, it is often better not to break it down. On the other hand where the impaction must be broken down, owing say to deformity as in Colles' fracture, it is generally well to begin by increasing the angular deformity so as to break the impaction.

Some writers insist upon the necessity of obtaining sharp *osseous crepitus* during setting as a sign that no muscle or other structure intervenes, and some even advocate rubbing the broken surfaces together to destroy any fragments of soft tissue which may intervene. When a considerable mass of soft tissue intervenes, or where the soft tissues are firmly attached to the broken surfaces as in transverse fracture of the patella, it is generally necessary to operate. Once the fragments have been brought into good position the extension and counter-extension should be maintained until the splint has been applied.

In cases, particularly of the lower limb, where there is great swelling, or suspected lesion of some important vessel, it is generally wise not to apply the splint until the swelling has subsided to a considerable extent, and the circulation is satisfactory. In such cases the limb may be placed between sandpillows. Were a splint applied at once gangrene might supervene.

Having chosen a splint of the proper type and size, and seen that it is well padded, it is applied according to the rules given later. But the work is not ended when it has been satisfactorily applied. The *circulation* must be seen to. A limb which has been put up firmly often presents slight venous congestion for an hour or so after application. This generally passes off, but the limb must be watched and the circulation tested by examining the pulse at the wrist or ankle, and the condition of the fingers or toes (which should always be left exposed), by pressing the nail, which should immediately blanch under pressure and become pink again when the pressure is removed. The patient should also be able to feel

the touch in the fingers or toes and be able to move them, but it should be remembered that a dead toe may be moved by a living muscle.

If these points are not quite satisfactory the splint must be taken down—to leave it would be to court gangrene.

Even where all goes well, and the circulation is quite satisfactory, the limb must not be left in the splint for the prescribed number of weeks without attention. In the first place the patient may have an undue amount of pain, and, when this is the case, the possibility of a pressure sore developing must be considered. *Pressure sores* tend most frequently to occur about the heel when it is not properly padded, and are generally characterised by fairly acute, well localised pain at the point of pressure, which lasts for several hours, or perhaps even for days, and then disappears entirely. The disappearance of the pain is not a favourable sign, as it is generally due to gangrene having supervened. Where the patient cannot locate the pain accurately it is generally a case of discomfort due to the constrained position rather than to pressure. The treatment for threatened pressure sore is immediately to relieve all pressure over the threatened area and to wash it well with spirit, repeatedly.

Although a splint may be quite firm when applied, it *becomes loose* after a few days, due to stretching of bandages, decrease of swelling, and to disuse atrophy of the muscles. It may then be necessary to take down and reapply in whole or in part. The *position of the limb* in the splint should also be observed from time to time, and any displacement corrected.

The *seat of fracture* should be examined occasionally after the fracture has been set to ascertain that the bones are still in good position, and that callus is forming. At a later stage the limb may be cautiously handled, either while lying in the splint, or carefully removed from it and supported, to find out whether the callus is becoming firm. Gentle massage should be given on

every occasion on which the bandages are undone. In all cases the fracture should be firmly united by the time the splint is removed. The patient, however, should not be allowed free use of the limb thereafter. It is now *placed between sandpillows* and regularly *massaged*, while joints, such as the knee, are *gradually flexed* by placing pillows under them during the day, and removing them at night. In the case of the lower limb the next step is generally to *encase it in plaster* and to allow the patient to go about *with crutches* and a high sole on the boot on the sound foot. Gradually he is allowed to put more and more pressure on the affected limb. By degrees the high sole and crutches are discarded, sticks being substituted for the latter: the plaster casing is removed, and finally the patient is allowed to use the limb in the normal manner. Thus the number of weeks a fracture of the lower limb requires to remain in splints represents only a portion of the total time required for treatment; as a general rule *about a hundred days*, and in some cases months are required before the limb is fully restored to activity, and the joints fully relaxed.

The Treatment in General of Fractures by Means of Extension.

Extension may be applied either by adhesive strapping or by pins driven into the bones.

Extension by use of adhesive strapping. Ordinary adhesive strapping about two and a half inches wide is generally sufficiently strong for use in the upper limb, but for the lower extremity special plasters are made for the purpose, failing which canvas or strong swansdown, three or four inches broad, may be employed, and fixed to the limb, which has been shaved, by a mixture of Venetian turpentine one part, rectified spirit two parts. A solution of celluloid in acetone, five to seven per cent., or surgical glue may also be used. The solution is painted

on to the limb and the canvas or swansdown (rough side down) immediately applied to it.

Bardenheuer recommended that the straps should in all cases *extend from the upper extremity* of the arm or thigh, and it is generally admitted now that it is a mistake to commence at the upper end of the lower fragment, as a limited area of skin has then to bear the whole strain, while only the lower portions of the muscles involved are affected. The strapping should extend at least to the level of the proximal joint, as thereby the whole tube of soft tissues is affected. Two straps, one on the inner, and the other on the outer side of the limb are generally sufficient. They should adhere firmly to the whole extent of the limb, except at the joints, opposite which folds of lint should be inserted, so as to facilitate passive movement, and at the malleoli, pressure upon which can be avoided by the use of a wide stirrup, into which the ends of the straps are inserted, and from which a cord runs over a pulley at the end of the bed to the weights. *Counter-extension* is applied by elevating the end of the bed on blocks. As a rule the straps must be reinforced by the application of a series of short, separate, encircling and overlapping bands of ordinary narrow adhesive plaster right up the limb, the joints being omitted.

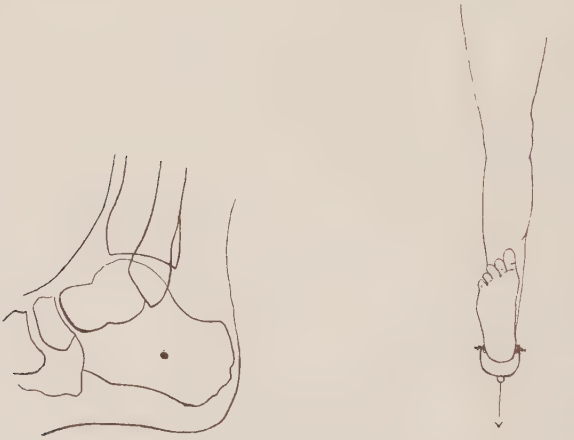
The patient is then anaesthetised, and the deformity reduced by the application of powerful extension and counter-extension which is kept up for several minutes with a view to overstretching the muscles, after which a weight of about twenty-five pounds is applied by the apparatus for fractures of the lower extremity in an adult and a full dose of morphia given to allay any pain which might be experienced when patient recovers from the anaesthetic.

Where the direct longitudinal pull alone is not sufficient to correct the deformity, recourse may be had to straps encircling the limb at the apex of the bend, from which cords run to weights hung over the side of the bed, which thus exercise *a transverse pull*, and if, instead of attach-

ing both ends of the encircling portion to the extension cord, only one end be attached, *a torsion pull* may be exerted to correct an inversion or eversion.

It will be seen that the need of such lateral pulls adds considerable complication to the process, and diminishes the efficiency of the longitudinal pull.

The objection to the plaster method in fractures of the lower limb is that when, in a difficult case, sufficient weight is applied to thoroughly correct the deformity,



Position of pin. Extension applied.

Fig. 3.—Extension by means of pin in os calcis.

either the plaster gives way or the skin breaks, and some other treatment has to be employed. It is generally quite efficient and satisfactory in use for fractures of the upper limb.

Extension by means of pins. The use of this method is almost entirely confined to fractures of the lower extremity.

A stout steel pin, fully six inches long and three sixteenths thick, which has either a sharp or drill point at

one end is generally employed. This pin may be hammered or drilled through the bone at certain points—namely the condyles of the femur, the malleoli of tibia and fibula, or *through the os calcis*. The last is, in the writer's opinion, undoubtedly the seat of election. It is well away from joints, and generally heals well, while the other sites are near joints which may easily be damaged and the wounds are frequently troublesome, healing being much delayed in some cases, and necessitating the use of Bier's suction cups and other devices.

A few seconds' anaesthesia with nitrous oxide or ethyl chloride is sufficient, and the operation is conducted on strictly aseptic principles. The prominent tubercles of the os calcis, lying well below and behind the malleoli are defined, a point about midway between tubercle and malleolous chosen, the skin is drawn slightly up so as to avoid traction on it once the weight is applied, and a puncture is made on one side down to the bone with a narrow bladed scalpel. The pin is then introduced through the puncture and hammered or drilled straight through the os calcis. When the point projects through the skin on the other side another small incision is made over it, and the pin is then driven through until the projecting portions are equal. The points of entrance and exit through the skin should be painted with collodion, and a little cotton wool dabbed on.

The point or points of the pin should be protected with caps—corks will do. The extension apparatus is then attached to the projecting ends of the pin, and a weight of from forty to fifty pounds for an adult femur is applied. Beyond a little discomfort at the heel, no pain is complained of as a rule, and patients who had previously been in splints have frequently expressed gratitude for the great relief the extension method afforded them. *Massage* may be begun at once and is generally agreeable to the patient. The very heavy extension is kept on for the first two or three days; the limb should be fully extended, and the muscles relaxed, while measure-

ment should show the limb to be fully as long as, if not slightly longer than, its neighbour. The weight is then gradually diminished, the rate at which this is done depending on the individual case. After two weeks twenty-five pounds will probably be sufficient in most cases. The pin should generally be removed after about four weeks, by which time the bone round about it has been absorbed, so that it is quite loose, and can be removed without an anaesthetic by the finger and thumb. Care should be taken, however, to thoroughly disinfect the projecting portion before withdrawing it through the wound. If the wounds are quite aseptic they may be sealed with collodion; if not, they should be painted with iodine and dressed. *Passive movement* should be given in addition to massage once the weight has been sufficiently reduced.

Where necessary an *ordinary plaster extension* with light weight may be employed after removal of the pin if the union of the fracture be not absolutely firm. Once union is firm the patient may be allowed up on crutches with a high sole on the boot on the sound foot, a plaster casing being applied if thought necessary to prevent accidents. Then the high boot is discarded, and later sticks are substituted for the crutches.

In the case of the *condyles of the femur* (which site is favoured by some on account of the supposed greater ease with which traction, with the thigh in the flexed position, can be applied), instead of transfixing the bone with a single pin, which, as already pointed out is certainly open to objection, a couple of nails may be used, one being driven into the condyle on either side. The object is to wound the bone as little as possible, but the aim may be attained much more successfully by the use of a horseshoe clamp, fitted with a pointed screw in either jaw. The screws may be driven a short distance into the bone on either side, or be so adjusted that they press firmly on the expanding ends without penetrating. Various modifications of the screw point have been

produced with a view to securing a firm grip without penetration. The horseshoe shape of the clamp lends itself to easy attachment of the extension cord. A somewhat similar horseshoe clamp may be used for the os calcis, penetrating points being fitted.

The great advantage of these methods of extending from the bones is that much heavier weights can be employed, with the result that complete relaxation of the muscles with consequent freedom from pain and accurate apposition of the fragments can generally be obtained without the use of lateral pulls or other adjuvants. Where the result is not perfect it can generally be easily made so by altering slightly the axis of the traction. If, for example, in fracture of the femur in the upper third, the upper fragment maintains a degree of flexion and abduction, the extension pulley should be shifted to the corner of the bed, and raised further from the ground.

Further, the limb is absolutely free from splints and bandages; its contour is obvious at a glance, and massage and passive movement can be carried out without any preparation.

Compound Fractures.

These may be produced either by the penetration of the soft tissues and skin by a sharp fragment of bone *from within*, after the fracture has occurred; or by the penetration of the skin and soft tissues by a foreign body *from without*, which, thereafter, coming into contact with the bone, fractures it. While both forms are apt to be septic, the latter is particularly so, the presence of the septic foreign body, the damage, infection, and consequent death of soft tissues and bone all tending in this direction. To this latter class belong many of the compound fractures due to machinery, and those due to gunshot wounds.

Gunshot wounds causing fracture are generally those due to revolver or rifle bullets, shrapnel, and frag-

ments of shell. *Small shot*, from a shot gun, is unlikely to cause fracture unless the distance be short and the shot has not had time to scatter in which case even the shaft of a long bone may be shattered. At a greater distance pellets may penetrate and become lodged in cancellous bone, near epiphyses, for example, while, if they strike a shaft, the pellets become flattened out on the surface of the bone. *Revolver bullets*, if sufficiently hard, and coming with sufficient force, tend to shatter hard bone, as they are comparatively broad-nosed and generally mushroom on impact with it. In other cases they may be deflected by the bone, or may flatten against it. In the case of cancellous bone they sometimes penetrate for some distance and become lodged, probably causing some splintering in the process.

Much has been written regarding the effect of *rifle bullets*, according to the distance from which the bullet has been fired ; but it must be remembered that a soldier has generally a very imperfect idea as to the distance from which he has been struck. A rifle bullet not only flies along the line of its trajectory, but spins on its own long axis owing to the action of the rifling of the rifle barrel. Were these the only movements one would expect that with its sharp hard nose and high velocity, a clean hole, with perhaps some cracks radiating from it, would be produced in a bone, and this sometimes happens. When, however, a bullet fired from close at hand or from a long distance fractures a bone it may cause *extensive splintering*. In the case of a bullet which is nearly spent this might be explained by loss of velocity and of spinning movement, but such an explanation does not account for what is frequently caused by a rifle bullet fired at close quarters. The explanation given to account for this phenomenon is that the bullet has not had time to settle in its flight, but wobbles for some distance after leaving the rifle. Opinions differ as to the precise nature of this wobbling, but perhaps the most generally accepted

view is that while the nose of the bullet keeps to the path of trajectory, the base flies round it in a circle, so that, were the bullet visible, it would look like a cone, with the apex directed forwards.

Other causes of comminution from rifle bullets are stripping of the hard outer coat; breaking off of the point (which is sometimes packed with paper internally) and ricochetting—the bullet striking and glancing off some other object before causing the wound.

The rounded bullets from *bursting shrapnel* tend to smash any bone they come in contact with, and the same may be said of the endless variety in size and shape of *fragments of shell*. The latter may, however, if sufficiently sharp, sometimes penetrate cancellous bone without causing much comminution.

Of course the *nature of the bone struck* has also much to do with the result. Thus hard brittle bone, such as occurs in the shafts of long bones, tends to splinter when struck, even when drilled by a rifle bullet, and in wounds of the shoulder the blade of the scapula is often found extensively splintered. Soft cancellous bone, on the other hand, is less likely to splinter and there is more chance of the metal lodging in it.

Compound fractures differ from other fractures in that, in addition to the damage done to the bone, one has always to consider the probability of *sepsis*, and treat accordingly. As already stated, the amount of sepsis varies in the two types of compound fracture, being generally less in that where the bone causes the wound. In the other form the kind of projectile, and the conditions under which the wound is received, are important factors. Thus rifle bullets even when causing damage to bone would sometimes in S. Africa produce wounds which healed with very little trouble, whereas a shrapnel bullet or fragment of shell in France often caused such sepsis as to necessitate amputation. The kind of organism introduced, the kind of tissue damaged, and the amount of that damage are all very important

factors, to which may be added the time which has elapsed since the injury was received.

With regard to organisms, the giving of prophylactic doses of *anti-tetanic serum* became an established practice in the present war. An immediate dose of at least five-hundred units was given, and followed by three similar doses at intervals of a week.

Gas gangrene also frequently met with in the recent war, caused by B. perfringens, B. bellonensis, vibrion septique etc., develops most readily where the wound of entrance is small and the laceration of muscle extensive; where the wound is in the buttock or lower limb, and less frequently in the shoulder, and where clothing or other foreign matter has been carried into the wound. Once gas gangrene has developed it may necessitate free excision of masses of tissue—particularly muscle—and not infrequently amputation. *Amputations* performed for gas gangrene should generally be of the flush type through muscles and bone, flaps of skin being first cut and then stitched in full eversion for the time being.

The dangers of extensive sepsis and gas gangrene may be minimised by early and efficient treatment, particularly directed in the case of threatened gas gangrene to combating low blood pressure.

Treatment. *In the first type*, where the damage of soft tissues is due to the bone, the bone should not be returned to its place until it has been thoroughly cleaned and disinfected. The wound area should first be carefully disinfected with some powerful and rapidly acting disinfectant such as Harrington's solution* or iodine, and the margin of the wound in the skin excised. The projecting piece of bone may be similarly disinfected; all

* Harrington's solution:

Hydrarg. Perchlor.,	·8 gramme,
Ac. Hydrochlor.,	30 c.c.,
Aq.,	300 c.c.,
Spt. Methyl.,	670 c.c.

fragments of bone or dirt removed from it ; sharp points rounded, and perhaps the surface shaved with a sharp osteotome or chisel. Thereafter the bone may be replaced, plated if necessary, and the wound brought together. The limb may then be placed in a splint, or extension applied by weight and pulley, or Thomas' splint. In all cases provision should be made for inspection of the wound, and dressing, should this prove necessary.

The treatment of comminuted compound fractures will be considered under the second type.

In the second type, where the damage is due to some foreign body which has entered the tissues from without, the damage may be great and the shock profound. In many such cases shock must first be dealt with (see section on amputations) and then the local treatment may be proceeded with. The first step is to get the skin and any exposed surfaces of muscle etc. thoroughly cleaned. The skin may be washed with soap and water —etherial soap is often of assistance in removing oily matter—and should then be swabbed over with Harrington's solution, after which, if the wound be comparatively small, its edges may be carefully excised, and then it should be opened up sufficiently to display the damage to the underlying parts. If, on the other hand, muscle and other tissues are already exposed and impregnated with dirt, these tissues may first be dabbed over with iodine, which stains them slightly, and then, if badly damaged, a thin slice is removed from the whole surface, the iodine stain directing one to parts which have been accidentally omitted. If the damage be not so great, ingrained material may be carefully picked out or excised, and this form of treatment is, of course, employed when in close proximity to an important vessel or nerve. The finger should carefully explore the whole extent of the wound, and all pockets must be thoroughly exposed and cleaned out. Unless this be done very thoroughly some pockets—such as frequently exist under the skin for example, and round about bones—are almost

certain to be missed, and then sepsis is equally certain to occur. Foreign bodies, not forgetting fragments of clothing, must be carefully sought for and removed.

Attention is next directed to the bone. If there be a bullet track through it, this may be cut out, a surgical bur doing the work well. Fragments of bone which are loose and ingrained with dirt should be removed, unless large, in which case they may be taken out, carefully shaved to remove all dirt, and then replaced. They must be kept warm during this process. Fragments which have attachments should if possible be cleaned and disinfected in situ, so as to preserve the attachments. If necessary a plate, screw, or wire, or combination of these may be employed to keep the parts in position, and then, having seen that haemostasis is complete, the wound may be closed, at least in part. As to whether drainage should or should not be provided, experience must guide. When in doubt, it is generally safer to leave in a drain, but, on the other hand, union is likely to be more rapid and thorough without one if all goes well. In the recent war the application of *bipp paste** to the surfaces of such a wound before closing was extensively employed. It tends to diminish capillary haemorrhage, facilitates drainage, and may perhaps stimulate the formation of granulation tissue. If used it should be applied in a thin layer over the wound surface by wiping with gauze dipped in the paste. A thick layer should never be applied and the paste should not be used as packing. In no case should the paste be applied to the bone surfaces: complete arrest of bone formation has followed injudicious use of the paste.

Where a *joint is involved*, with fracture of the bone, the same lines are followed, and once all contaminated tissues

* Bipp paste (two formulae):

Bismuth subnit.,	gr. 220,	1 part by weight.
Iodoform, -	gr. 440,	2 parts ,,
Paraffin (soft), -	gr. 220,	(liquid) 1 part by volume, or q.s. to form a paste.

have been excised, the joint is closed without a drain—even if it be necessary to drain the more superficial tissues.

After operation the limb may be put up in extension, either by use of an extension apparatus such as has already been described, or of a Thomas' splint, or it may be encased in plaster, and a skiagraph should be taken to verify the position. In all cases, whether joints are involved or not, the movements of the various joints and muscles should be carefully attended to. French surgeons generally favour immobilisation of a wounded joint for several days after operation, but appear to be agreed that movement should begin within a week or ten days of injury.

In many cases of compound fracture due to machinery or fragments of shell, the damage is so great, or the infection so intense, that *amputation* must be performed in order to save the patient's life. While the primary object of such an amputation is to remove the hopelessly damaged or infected tissues, the beginner must remember that he may gravely influence his patient's prospects in after life by an injudicious amputation. The recent war has given an immense impulse to the production and fitting of artificial limbs, and a special chapter is therefore devoted to the consideration of amputations with a view to subsequent fitting with a serviceable artificial limb.

Healing of Fractures.

In order to understand the healing of fractures, it is necessary to know something of the *minute structure of bone*, particularly that which constitutes the hard shafts. One is apt to look upon such bone as dead material, but it must be remembered that, while the inorganic bone of a skeleton is dead, during life that bone is so crowded with bone cells which influence every particle of it, that, to all intents and purposes, it may be regarded as being alive. Perhaps an analogy may be found in coral, which we are accustomed to consider as an orna-

mental but dead substance, but which during life is known to teem with polyps, which, like the bone cells, have the power of building up and removing the coral as they desire.

If then we examine a section of hard shaft under the microscope, we find that it presents a large number of Haversian canals, which communicate freely with one another, and along which vessels, lymphatics, and nerves, accompanied by a thin envelope derived from the periosteum, run, having gained access from the surface of the

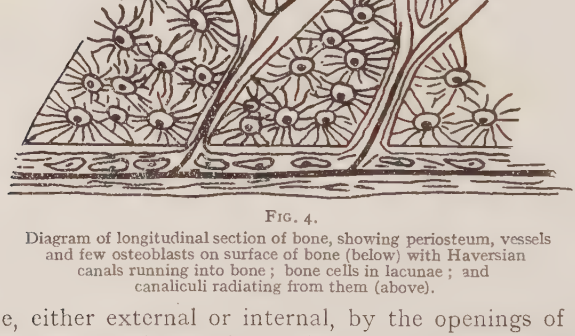


FIG. 4.

Diagram of longitudinal section of bone, showing periosteum, vessels and few osteoblasts on surface of bone (below) with Haversian canals running into bone; bone cells in lacunae; and canaliculi radiating from them (above).

bone, either external or internal, by the openings of the Haversian canals at these places. The bone cells lie in spaces or lacunae, which are very numerous, and which communicate with the Haversian canals, and with one another, by means of minute canals or canaliculi, and along these canaliculi processes of the bone cells run, so that the cells might be compared in shape to star fish with large numbers of arms. By means of the canaliculi the bone cells receive nourishment from the vessels in the Haversian canals, and also receive nervous impulses, whereby they are kept in touch with what is going on in the body generally.

The *periosteum* is not firmly attached to the surface of the shaft, but is held in position by the processes

PLATE I.

Section of a Haversian Canal on right side of which two osteoblasts are seen escaping from lacunae the walls of which they have absorbed. Note general enlargement of lacunae.

Enlarged Haversian Canals crowded with osteoblasts proceeding to surface. Note dilated mouth of canal discharging osteoblasts on surface under periosteum.

entering the Haversian canals and by loose areolar tissue, and in the interstices of this tissue, at least in young persons, are numerous bone cells lying free on the surface of the bone. The *blood supply* received through the periosteum is of considerable importance in young persons, but is less so as age advances, the supply through the nutrient artery being then more important. On the inner surface of the hard shaft there is an extremely delicate membrane separating the bone from the medulla, and, on this surface, the vessels entering the Haversian canals are derived from the nutrient artery.

The writer has carefully investigated the healing of fractures by means of experimental research, and he would ask students in trying to understand the subject, to regard the healing of bone as quite akin to the healing of any other tissue in the first place and to regard the specific action of the osteoblasts as secondary. Beyond acting to a slight extent as a limiting membrane and carrying blood to the cells, the periosteum takes no part in the process.

Healing of Fractures. The Process.

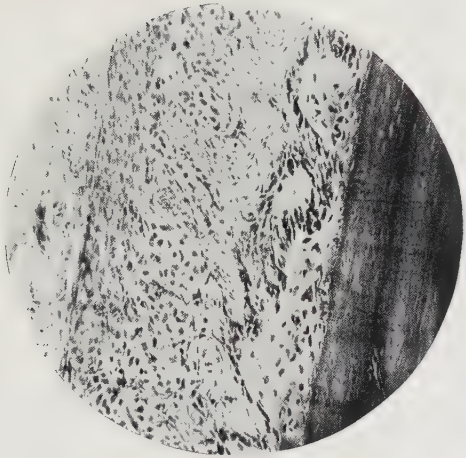
All wounds heal by granulation tissue, and, in this respect, fractures do not differ from other wounds, and indeed, in most of the chief phenomena the healing processes are very similar. When a bone is broken there is a solution of continuity, with damage to hard shaft, medulla, and periosteum. In consequence of this there is haemorrhage between the broken fragments and into the surrounding tissues which have also been damaged. Such blood as does not escape into the soft tissues coagulates and later is gradually removed by the emigration of leucocytes in large numbers which act as phagocytes, and which also remove all damaged cells of the fixed tissues in the affected area. The small spaces thus formed by the activity of the leucocytes are gradually filled up by granulation tissue.

Granulation tissue consists of embryonic cells derived from the various fixed tissues which have been damaged, nourished by embryonic blood vessels derived from, and communicating with, the pre-existing vessels of the medulla, shaft, and periosteum. These minute vessels are at first very numerous and hence the granulation tissue is markedly vascular.

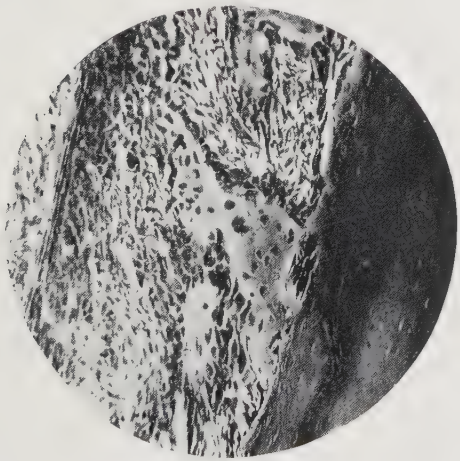
In wounds of soft parts the cells of the granulation tissue are largely fibroblasts, but, in wounds of bone, while many fibroblasts are present, *osteoblasts* predominate. These **osteoblasts** are embryonic bone cells, just as fibroblasts are embryonic fibrous tissue cells; and they are derived from adult bone cells just as fibroblasts are derived from adult fibrous tissue cells. Further, as fibroblasts become converted into adult fibrous tissue cells so osteoblasts become adult bone cells. The chief function of a bone cell however is to lay down inorganic bone matter: but more than this, it can act as an *osteoclast* and absorb bone, act as a *chondroblast* and deposit cartilage or as a *chondroclast* and absorb cartilage.

How do the bone cells get out from the bone and travel to the seat of fracture? When the fracture occurs those bone cells which are nearest to the Haversian canals absorb the bone by which they are surrounded by their osteoclastic action, and are thus set free in the Haversian canals. The canals are at the same time enlarged by the amount of space previously occupied by these bone cells and the bone surrounding them. Large numbers of bone cells thus set free travel down the enlarged Haversian canals, until they reach the surface of the bone under the raised periosteum, or the seat of fracture, movement being effected probably by amoeboid action. Cells not so favourably situated as regards a Haversian canal probably first of all undergo division by fission or karyokinesis and the young cell or osteoblast thus produced ultimately finds its way into a Haversian canal and so proceeds to the scene of action. Thus at an early stage the Haversian canals near the seat of fracture

PLATE II.



External Provisional Callus. Osteoblastic granulation tissue on surface of shaft close to point of fracture. New bone formation is commencing on surface of shaft and while some cells are embedded in the new bone forming the bone cells, the osteoblasts generally are arranging themselves on the periphery of the spicules of new bone.



Slightly later stage than former. New bone forming on surface of shaft round an enlarged Haversian Canal blocked with osteoblasts. Note continuation of Canal in the shaft.

are seen to be enlarged and filled with osteoblasts making their way to the surface, while those osteoblasts which normally lie on the surface under the periosteum are engaged almost at once upon new bone formation.

The osteoblasts, then, are poured out into the spaces in the blood clot left by the phagocytic action of the leucocytes, being derived chiefly from the hard bone shaft, as described, and to a slight extent from its inner and outer surfaces. Gradually the whole of the blood clot is replaced by the osteoblastic granulation tissue, which steadily increases in quantity, not only between the broken ends of the bone, but also on the inner and outer surfaces of the shaft, at which latter part it may push the periosteum before it, or may infiltrate and destroy it. To this mass of osteoblastic granulation tissue, once bone formation has begun in it, the name of CALLUS is given. *Provisional Callus* is that which forms on the outer and inner surfaces of the shaft of the fractured bone. It acts as a temporary splint and is gradually removed when no longer required. *Definitive callus* is that which is formed between the broken fragments and which takes part in the permanent union of the fragments.

FIG. 5.

A Provisional callus.
B Definitive callus.
C Medulla.
D Hard shaft.
E Periosteum.

New bone formation occurs first in the osteoblastic granulation tissue deposited on the surface of the shaft under the periosteum, and is visible about the third day after fracture. The new bone extends down toward, but generally stops short of, the actual point of fracture. It is laid down by the osteoblasts round the new vessels, and, as these vessels communicate with the pre-existing ones in the Haversian canals, the continuity of the Haversian system between new and old bone is preserved.

Direct bone formation in Callus. At the point where new bone is required a few osteoblasts, generally less

crowded than those by which they are surrounded are seen to become slightly obscured by the deposition of new bone around them, so that they become embedded within the material, and thus become young adult bone cells, being roughly spherical in shape. Immediately a bony nucleus is formed, the adjacent osteoblasts arrange themselves round the periphery and become actively engaged in laying down further bone so that the spicule rapidly increases in size. The osteoblasts in the periphery are ovoid or columnar in shape, with the end in contact with the new bone tapered, apparently with the object of permitting as many cells as possible to take a share in laying down bone. It is possible that a little of the *osseous matter* is derived from the previous absorption of the adult shaft by the bone cell, but most of the material is probably derived from the blood stream.

Cartilage formation in callus. While direct bone formation is generally observed on the outer and inner surfaces of the bone at a little distance from the point of fracture, there is generally, at least in animals, and particularly where movement of the broken fragments is permitted, or apposition of fragments is faulty, a considerable area of intermediate cartilage formation, especially between the broken ends, and in the more peripheral portions of the provisional callus. The object of cartilage is probably to provide a large firm splint which will, as soon as possible, keep the bones in position while ossification is progressing, but which will yield rather that break when some unusual bending force is applied. Just as the osteoblast can lay down bone around its periphery, converting itself into an adult bone cell, so it can act as a *chondroblast* and surround itself with cartilage, and become a cartilage cell. When acting in this capacity the cell is generally distinctly larger than when acting as an osteoblast, and is surrounded by a halo which probably represents the real limit of the cell membrane.

Thus in a given time a given number of osteoblasts are capable of forming a greater quantity of cartilage than of bone, and this power is increased by the deposition of clear cartilaginous intercellular substance in considerable quantity in some cases. While vessels are difficult to make out in this cartilaginous mass in the early stages, the mass becomes very vascular in the later stages, large vessels permeating it in all directions prior to the formation of the bone.

Indirect bone formation in callus. In the indirect formation of bone—that is, with an intermediate cartilage stage—bone begins to be laid down in the clear cartilage close to a vessel by the cells in that region. The cartilage becomes cloudy and indistinct owing to the deposition of bone in it, and, once a spicule has formed, the surrounding cartilage is rapidly broken up, the cells acting as chondroclasts, and once the cells are free they resume their functions as osteoblasts and apply themselves to the periphery of the bony spicule as already described.

The *callus now becomes markedly vascular*, the blood supply being chiefly derived from the medulla, which, becoming very active, forms a large vascular mass of callus which sweeps round the broken ends of the bone and joins the external or ensheathing callus.

Healing of extremities of broken shaft. Formation of new bone is not generally very active at the broken extremity at first, due, perhaps to defective blood supply, or to a capping action of the soft tissues. The enlargement of the Haversian canals in this region, however, is marked, and these now become so large as to form cavities in the ends of the bone. Gradually callus extends into these spaces from the mass between the broken ends, in finger-like projections, sometimes composed of direct forming bone, and at others of intermediate cartilage. The effect of this hollowing out and finger-like projection into the hollows is to provide a very firm junction between the old shaft and the new forming bone.

Later stages. After a time the cartilage gradually disappears, and is replaced throughout by bone; and this new mass of bone occupies the medulla; the interval between the ends of the hard shaft, and forms a spindle-shaped mass on the outer surface of the bone, extending a considerable distance above and below the point of fracture. It also extends laterally outwards having permeated and obliterated the original periosteum, which, at this part, is now replaced by a new periosteum which covers the outer surface of the callus. As ossification becomes complete throughout, the callus becomes hard, and the union firm, so that the patient is able to bear the weight of the body on the affected bone once more. At a still later stage re-absorption of the provisional callus takes place so that the cavity of the medulla is gradually restored, and ultimately even the external ensheathing callus may more or less entirely disappear, the normal contour of the bone being restored in favourable cases.

Factors influencing callus formation. The amount of provisional callus formed in a given case depends upon several factors, among which may be mentioned the amount of displacement of fragments, amount of damage done, position of the fracture, and subsequent movement.

In some cases the callus may form a very large mass which not only renders the bone bulky and heavy but may interfere with the movements of muscles and even with the action of nerves which may become caught in it, giving rise to pain or paralysis. Generally, however, a new periosteum is provided for it by the surrounding tissues, and this periosteum, while it supplies the bone with blood, also acts as a limiting membrane, keeping the growth of bone within limits. But movement during this period, *or injudicious massage*, may lead to the periosteum being again infiltrated and replaced by new bone which in some cases has been known to form large masses in the surrounding muscles. Where a fracture is

PLATE III.

Mass of new bone formed in muscle after injury to shaft of femur, due to injudicious, vigorous "massage" which drove the osteoblasts into the muscle and stimulated their action.

From Sir Wm. Macewen's *Growth of Bone.*

comminuted the amount of callus is generally very considerable, each broken splinter of bone acting as a focus for the dissemination of osteoblasts.

Fractures about epiphyses. The position of fracture also influences the amount of callus formation. The bone of which the epiphyses are composed is not nearly so rich in osteoblasts as that of the diaphyses, and therefore, when a fracture occurs near a joint, the amount of callus formed is generally comparatively slight. This is a wise provision of nature because in the first place the broken surfaces near a joint are generally broad and the displacement comparatively slight, and hence there is not the same need of splinting, while, in the second place, were much callus formed in such a position the movements of the joint would probably be much restricted.

Callus luxurians, or tumor-like formation of callus is rare apart from such conditions as have been described. While some writers describe such a condition as developing into sarcoma it is probable that, in many instances, the sarcoma was first present and was the cause of the fracture occurring.

It should be borne in mind that callus is generally not shown by X-rays at least until a later stage, so that an examination by X-rays is generally of less value in early stages in showing how the callus formation is progressing.

Rarely, and particularly after local infective processes, callus has been reabsorbed after being laid down.

Delayed union and non-union. The time required for a fracture to unite firmly varies greatly, and is influenced by the health of the individual, the bone affected, and the method of treatment adopted. Rickets, syphilis, scurvy, and old age are generally enumerated as factors militating against union, but ricketty bones certainly unite perfectly once the active stage has been passed by the particular bone, as is evidenced in the treatment of genu valgum by osteotomy. As regards the bone affected, large bones, and those of the lower extremity,

generally require a longer period than others. It is a point frequently urged against the use of splints, that, even when the bone is united, the joints and muscles have been so impaired from disuse that the limb is unfit for work for a prolonged period, whereas, when extension is used, massage can be applied regularly during the period of treatment, and these structures kept in comparatively good condition.

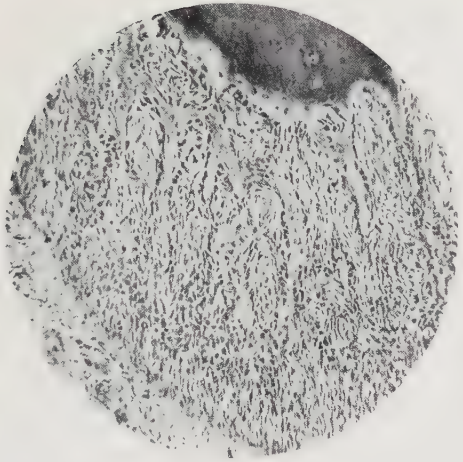
Where a bone does not unite in about the average time for that particular bone, *delayed union* is said to have occurred, while, if union remains imperfect or does not occur, it is spoken of as *non-union*. Non-union most frequently occurs from interposition of soft tissues between the fragments or from faulty apposition, or from undue movement during the healing period, and attempts may be made to rectify it by stimulation such as rubbing the ends together under an anaesthetic; by gently pummelling the area with the fist; by the application of Bier's passive congestion; or, if these fail, by operation, with refreshing of the broken ends, and fixation in apposition.

Absolute non-union may occur where the fragment detached is almost deprived of blood supply, as in the head of the humerus, and, to a less extent, in the head of the femur. Possibly the interposition of synovial fluid between the fragments may also have an effect in such cases.

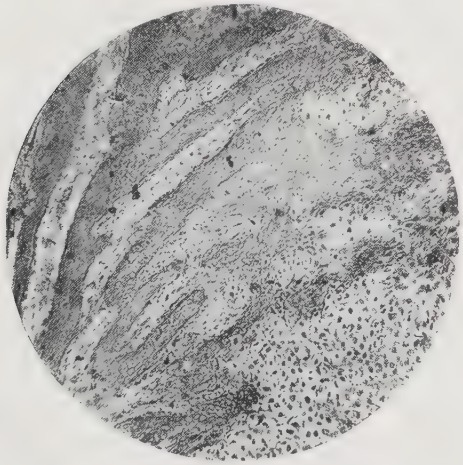
In some cases of non-union with death of a portion of the bone, *bone grafting* may be necessary to remedy shortening.

Fibrous union is generally very unsatisfactory, as the fibrous tissue stretches and the fragments move upon one another and tend to separate. Sometimes a *false joint* may form at the point of fracture following upon fibrous union.

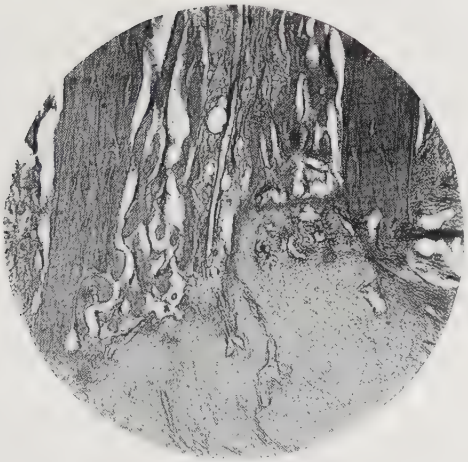
Apart from the injury to the bone, the *soft tissues* in the neighbourhood are also generally injured, either by the fracturing force or by the fractured bone.



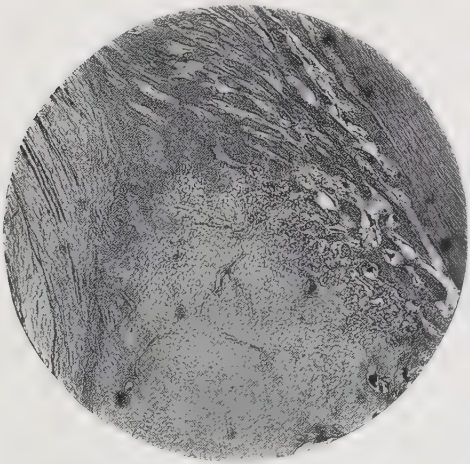
Almost complete conversion of osteoblastic granulation tissue into new bone by direct bone formation. Periosteum infiltrated and destroyed.



Cartilage in Callus, and indirect bone formation.
Traces of cartilage formation can be seen even within the spicules of new bone about the centre of the diagram. New bone on extreme left has probably been formed by direct process.



Extremity of Broken Shaft showing extremely vascular medulla, mass of vascular definitive callus, and greatly enlarged Haversian canals forming cavities in ends of hard shaft.



Provisional Callus, close to point of fracture, in advanced stage. Note mass of new bone above and of vascular cartilage below: indirect bone formation at junction. On the left is a mass of muscle slightly infiltrated by new bone. No trace of periosteum.

Muscles are generally stretched and contused, while they may also be lacerated or penetrated by broken fragments.

Blood is frequently effused into muscle, and clots, adding thereby to the rigidity. On the other hand, muscle may become interposed between the broken fragments, particularly when the fracture is oblique or spiral.

Volkmann's ischaemic paralysis is a condition which arises from interference with the blood supply of muscles, most often in fracture about the elbow or forearm, but sometimes in the leg. The condition may develop within a few hours of the fracture being sustained, and while in some cases it may be due to pressure of the splints, it certainly is not always so. Gross damage to the muscle substance at the time of injury, or pressure of the broken bone upon a vessel are possible causes.

The affected muscles swell, and become hard and painful, while later the fibres necrose and contract, producing deformity. The flexor muscles of the forearm are most frequently affected, a claw hand being produced, with hyperextension of the proximal phalanges of the fingers, and flexion of distal phalanges. If, however, the wrist be fully flexed, the fingers can be passively extended. The hand and fingers become swollen and blue; there may be considerable pain, and occasionally pressure sores develop.

With a view to avoiding such occurrences, the pulse should always be examined repeatedly after a fracture is put up, and, particularly when the elbow or forearm is affected. If the pulse is not satisfactory, the splint should at once be removed, and the cause of the obstruction sought and steps taken to remove it, if necessary by operation.

Arteries may likewise be damaged, the rupture being either partial or complete. In either case haemorrhage into the tissues will result, sometimes with the formation of a traumatic aneurism. Gangrene, either local or

general, may follow: local, of the parts in the neighbourhood, from pressure of the effused blood upon them; or general, below the point of lesion, from interference with the arterial supply. *Ligature* of an artery is generally difficult in such cases owing to the great infiltration of the tissues with blood, and sometimes amputation may be necessary.

Veins are most often damaged in association with the accompanying artery, and the risk of gangrene is increased thereby. Veins may also become thrombosed, particularly where splints are employed and the patient is elderly or the veins varicosed. Oedema frequently develops in consequence. Care is required in dealing with such cases as embolism may follow, generally within a month of the accident. Massage must not, of course, be permitted.

Nerves may be compressed, contused, or torn, or cut across by sharp fragments, while in later stages they may be involved in callus. Paralysis, complete or partial, or neuralgia may be caused, and may necessitate operation. Where a nerve has been divided it should immediately be sutured. The nerves most frequently affected are the musculo-spiral and external popliteal, and then the ulnar and median.

The term *Late Paralysis* is sometimes applied to paralysis coming on many years after a fracture, the condition being rarely seen in adults who, in childhood sustained a fracture, generally of the lower end of the humerus, following on which irritation of the ulnar nerve gradually developed.

INDIVIDUAL FRACTURES

Skull.

Fractures of the skull may involve the vault or base, or both. Those of the vault are generally caused by *direct violence* while those of the base are due to *indirect violence* or to extension from the vault. Fracture of the base by direct violence is occasionally caused by the projection of a sharp object through the orbital roof from the eye socket, or through the cribriform of the ethmoid from the nose, or by a blow on the nape of the neck with fracture of the posterior fossa.

Fracture by *contre coup*, in which the fracture occurs at a point diametrically opposite to that struck, has rarely occurred at the cribriform of the ethmoid from a blow on the occiput.

Where the tables of the skull are widely separated, as at the frontal sinuses, an *incomplete fracture*, involving one table alone, may be produced. As a rule, however, fractures of the skull are complete, and may be fissured, punctured, depressed, elevated, or comminuted. They may also be simple or compound, and many fractures of the base, involving the anterior or middle fossa, are compound on account of communication with the nose, ear, or pharynx. Damage to the contents of the skull is generally of much greater moment than the fracture itself, and therefore the fractures are grouped according to whether damage to the brain is likely to be non-existent or slight, or is likely to be considerable.

Group I. *Fractures, generally involving the vault, in which damage to the brain is slight or localised.*

A blow from a sharp pointed instrument, such as a dagger, tends to produce a punctured wound rather than a fracture, while that from a sharp edged instrument may cut partially or entirely through the bone, perhaps with fissures running from either end of the cut. If the blow be oblique a portion of bone may be detached or elevated. A moderate blow from a blunt edged or pointed instrument may break the external table and crush it into the diploe if the bone be thick, or, if it be thin, may perforate the skull. A violent *localised* blow, as from a hammer, generally produces a fracture of the depressed type—*pond* or *gutter*—due to a bending of the bone, from which radiating fissures may extend due to a bursting action. In such cases the internal table is generally more extensively damaged than the external, and may be driven into the brain causing considerable damage.

Group II. *Fractures, generally involving the base, either alone, or by extension from the vault, in which a lesion of the brain is generally the most clamant feature.*

When *diffuse violence*, such as a crushing force, is applied to the skull, a *bursting fracture* tends to occur, the fracture generally starting from about the point of impact, and travelling across the skull in the direction of the fracturing force. Should the force continue to act after the fracture has developed, a second fracture may be caused at right angles to the first, due to a *bending* action.

When *indirect but localised violence* is applied to the base of the skull, causing fracture, there is generally accompanying damage to the brain. Such conditions are seen in fracture of the cribriform or orbital plate of the frontal from blows on the frontal; and in the middle fossa in fractures caused by driving of the condyles of the jaw against the glenoid as from falls on the chin.

Other forms of indirect but more diffuse violence causing fracture of the base, and generally damage to the brain, are fractures of the sphenoid from falls on the feet; and ring fractures caused by falls on the feet or buttocks, or by falls on the vertex. The *Ring fracture* occurs on either side of the foramen magnum and extends forwards, perhaps to the jugular foramen, or the two portions may unite at the sella turcica.

Bullet wounds of Skull. A *rifle bullet* at close range may, by disrupting the brain, burst up the whole skull. At a distance it causes a wound of entrance with greater damage to the inner table, and a wound of exit with greater damage to the external table. At still greater distances it may lodge in the brain. Tangential impact of a bullet causes a gutter fracture, and the writer saw numerous cases in S. Africa and France in which, although the bullet had only ploughed through the external table, the internal table was extensively fractured and portions driven deeply into the brain which was much lacerated thereby, necessitating immediate operation.

A *Revolver bullet* tends to produce a wound of entrance with radiating fissures round it, and it often lodges within the skull.

The pellets of *small shot* fired at short range from a shot gun, particularly if of choke bore, may by united action smash the skull and penetrate the brain, while isolated pellets wound a wide area of surrounding scalp.

The *Symptoms* arising from injury to the brain from bullet wounds depend upon the parts affected and the amount of damage done. Sudden death may be caused by destruction of or pressure upon the medullary centres. Signs of localised irritation or paralysis may be due to the track of the bullet and need not indicate its whereabouts. Signs of compression are generally due to haemorrhage, which may occur also into the ventricles, so that the whole cerebro-spinal fluid becomes mixed

with blood, as evidenced by lumbar puncture. As a rule the *prognosis* is more favourable where the damage is confined to the frontal lobes.

Treatment. Where the bullet is lodged in the brain and is not giving rise to symptoms, it is probably best to leave it, at least at the time of the injury. Where, however, there is evidence of considerable intracranial haemorrhage, or of damage due to portions of skull having been driven into the brain substance, immediate operation should be done on the lines indicated in treatment of compound fractures. The wound in the soft tissues and skull is cut out, and after careful cleansing of the dura the tear in it is opened up and the brain explored for the bullet and fragments of bone, which are then removed. Similarly, blood clot and disrupted brain matter should be assisted to escape, and then a superficial dressing may be applied to facilitate exit of any further discharge.

Fractures of the Vault. *Symptoms and Diagnosis.* Fractures of the vault can generally be recognised by palpation, and, if the scalp be wounded the fracture may be visible as a thin red line. Several mistakes, however, are apt to be made. Where, in consequence of a blow, a *haematoma of the scalp* has formed, the raised margin, due to peripheral heaping up of the tissues and clotting of the blood, is apt to be mistaken for the edge of the skull, while the central portion, lying at a lower level, and containing liquid blood seems to represent a depressed fracture. In order to differentiate, firm pressure should be made for several seconds on the raised periphery. If it be the edge of the broken skull, the edge will be rendered more obvious by the pressure, whereas, if due only to soft tissues, the apparent edge will be dissipated by the pressure.

Where there is a *scalp wound*, this should always be carefully explored for fracture, after disinfection of the surrounding parts and edges of the wound, by the finger. Here again mistakes may be made, an antero-posterior

slit in the aponeurosis of the occipito-frontalis muscle sometimes resembling a fracture to touch, while sutures of the skull may similarly be mistaken. In addition to the normal sutures, it should be remembered that *foetal sutures* sometimes persist. The most common is one which extends up from the foramen magnum toward the occipital protuberance, or even beyond it, while lateral sutures may run in and join it at the occipital protuberance. *Fissures* also sometimes persist in the posterior portions of the parietals. *Wormian bones* exist more frequently about the lambdoidal suture, and an *os epactal* sometimes exists at the apex of the occipital. A scale like *epipteric bone* at the tip of the great wing of the sphenoid may suggest a separation of the tip.

Percussion of the skull is often of value, the fractured area yielding a note of lower pitch, while a cracked pot quality is sometimes detected, and the region is generally tender to percussion.

Fractures of the Base. Fractures of the base cannot generally be palpated, and a diagnosis must therefore depend upon other signs.

Anterior Fossa. Fracture of the Anterior Fossa may be accompanied by bleeding from the nose, and, if the anterior extremity of the longitudinal sinus is torn, the blood may come in gushes which distend the nostrils. The escape of cerebro spinal fluid is more definitely diagnostic, as blood may come from injury to the mucous membrane of the nose. Brain matter rarely comes down through the nose. Emphysema of the soft tissues about the eye or cheek may occur from forced expiration.

Where the *orbital plate of the frontal* is fractured blood generally finds its way forwards, under the conjunctiva, and also into the eyelids.

It is important to discriminate between this condition and ordinary '*black eye*,' due to a blow on the eye, with consequent effusion of blood into these parts.

In black eye the discoloration comes on immediately

or within a few hours of the injury, and is diffused generally over the eyelids and conjunctiva, the colour being generally of a dark red or chocolate : whereas, in fracture of the orbital plate the blood does not appear for a day or so ; is patchy ; occurs first generally under the conjunctiva where it is of a bright red colour, and later in the eyelids, where it is generally dark blue.

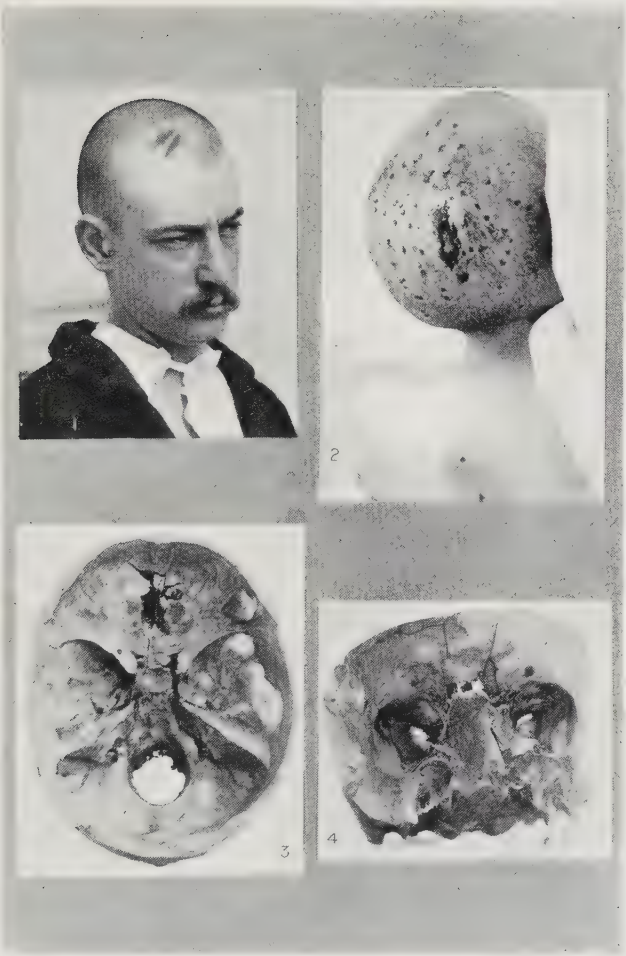
In black eye it is generally possible to see the limits of the area of discoloration, by getting the patient to turn the eyeball in various directions, whereas, in fracture, the track of the blood at some point runs backwards along the eyeball as far as it can be traced.

In black eye, the blood is in the conjunctiva, and therefore moves with it, whereas, in fracture it is under it, and the conjunctiva can therefore be moved over it. It is seldom necessary to touch or pick up the conjunctiva in order to perform this test. In the case of fracture the movements of the conjunctiva over the blood when pressure is made upwards from the lower eyelid are generally easily seen, if the patient keeps the eye open, and a good light is used.

In some cases of fracture of the orbital plate there may be in addition proptosis, or pushing forward of the eyeball, and the patient may complain of flashes of light due to irritation of the optic nerve.

Middle Fossa. In fracture of the middle fossa there is frequently bleeding from the ear. As blood may come from injury to the external meatus or rupture of the drum, the escape of cerebro spinal fluid is more diagnostic. Rarely small portions of brain matter may escape. Hernia cerebri is described as occurring but must be excessively rare if it does occur. Emphysema may rarely occur over the mastoid region on forced expiration if the fracture extends through that process.

Nerves may be damaged, either by the fracturing force or fractured bone, or by subsequent pressure of effused serum or blood. Two are of particular importance, the third and facial nerves.



(1) Depressed fracture of skull.

(2) Small shot wound penetrating skull and causing death.

(3) and (4) Fracture of skull in region of frontal sinuses from great direct violence extending to base and involving all three fossæ.

Where the *third nerve* is slightly pressed on, and therefore irritated, the pupil on the affected side is contracted and sluggish, whereas if the nerve be crushed the pupil on the affected side is dilated and fixed. Where the nerve is put entirely out of action other phenomena will occur, such as ptosis, fixation of the eyeball with external rotation, etc., but the pupillary phenomena are extremely delicate, and therefore of much value in diagnosis.

When the *facial nerve* is affected, there is facial paralysis on the affected side. Some observers state that this condition generally comes on some days after injury, but it should be remembered that, when a patient is unconscious, and lying absolutely still, a facial paralysis may easily escape observation.

It is often of importance to determine whether a facial paralysis is due to a lesion of the facial nerve or to a *lesion of the motor cortex*. Of course, when the nerve is affected, the paralysis is on the side of the lesion, whereas, when the cortex is affected, the paralysis is on the opposite side, but when it is doubtful which side the lesion is on, both sides being damaged, as frequently happens in several basal fractures, then a further test is necessary. When the facial nerve is destroyed, the facial paralysis on the same side is absolute; whereas, when the face centre is affected, the opposite side of the face is only partially paralysed, the mimetic play of the features being retained. Thus, when the patient blinks the eyelids, both sides move, and when he smiles there is a slight wrinkling of the face on the affected side. Deafness from injury to the ear or to the auditory nerve may also occur.

Pharyngeal ecchymosis may develop later.

When the fracture runs near the pterion the *middle meningeal artery*, which runs in a groove, and sometimes in a canal in the bone, is often torn, with the result that a haematoma occurs inside the skull, and steadily increases in size. This causes compression of the brain from which the patient may die unless at once operated on.

Posterior Fossa. Fractures of the posterior fossa do not give rise to equally definite symptoms. There is generally pain and tenderness on pressure over the mastoid region and posterior triangle of the neck, and ecchymosis may develop over these regions and over the pharynx a few days after the accident. Movements of the tongue and of swallowing are sometimes impaired.

Complications.

Fractures of the skull attain much of their importance from the injuries to the brain and its membranes which so often accompany them, and the diagnosis and treatment of these injuries are generally of greater importance than are those of the skull itself.

The cerebral conditions which require special attention are concussion, compression, contusion, laceration, hernia cerebri; haemorrhage from the middle meningeal artery or venous sinuses; subdural haemorrhage; microbic infection of the meninges, cerebro-spinal fluid, and brain.

Warning to house Surgeons. It cannot be too strongly insisted on that a patient who has a fractured skull may be not only conscious, but able to walk about and speak coherently: further, that an odour of alcohol from the breath is not necessarily evidence that the patient is intoxicated, as many good samaritans give an injured person alcohol with a view to helping him after the accident; and still further that a man may be drunk, and yet have his skull fractured. These may appear ridiculously obvious statements but beginners should ever bear them carefully in mind. Many a patient has been neglected, or even sent home, on the ground that he is intoxicated, when in reality his skull has been fractured and he has died within an hour or so of being refused admission to hospital, with the result that the public who do not realise the ease with which a mistake is made blame the doctor severely in such cases.

With a view to impressing these points the writer may relate a case which occurred when he was a house surgeon. In the midst of an operation at which he was assisting, he was asked to see a man who had been admitted, who had had his head hurt. He found a man walking about the corridor, who immediately turned to him saying he did not know why he was brought here, there was nothing whatever the matter with him, and if an attempt were made to keep him against his will he would make it hot for those concerned. Two points were noted, first, that the man was unduly excited, and second, that his right pupil was slightly smaller than the left and was sluggish (from irritation of the third nerve). The ambulance man, who was present, said in an undertone that he knew the man had landed on his head from a considerable height, and that he was unconscious when he picked him up (concussion). The patient was finally persuaded to remain until his friends came, who could decide whether he should stay or go home. He was got to bed, and his head shaved, and before the operation at which the writer was assisting was finished, a message came that the man was unconscious (compression). He was immediately brought to the theatre, the pupil which previously was contracted was now widely dilated and fixed (from paralysis of the third nerve), the skull was opened and a large haematoma, due to tearing of the middle meningeal artery, was found. Had this man been allowed to go as he desired, he would have died on the way, and few would believe that half an hour previously he had been threatening any who dared to keep him against his will.

Concussion. In most cases of severe fracture of the skull there is a period of concussion, which may be transitory, or may persist. The patient generally loses consciousness at least momentarily, and he may die immediately. If he survive, and the concussion persists, the surface of the body is pale and cool, and frequently covered with sweat. The respirations are shallow and

sighing ; the pulse slow and small, and the pupils medium or dilated. The muscles are relaxed. Urine and faeces may be passed automatically. Reaction is ushered in by vomiting, contraction of the pupils, and a rapid bounding pulse. Should the patient remain comatose, it is probable that the concussion is merging into compression.

Compression. Compression generally comes on more slowly, as in the case of haemorrhage related above, and if there be no previous concussion, is ushered in with headache, restlessness and irritability. Soon the patient becomes unconscious. The skin is hot and flushed, and perspiration is profuse. The breathing is noisy, puffing and stertorous. The pulse is slow and full. There is retention of urine, with subsequent overflow if not relieved, and the bowels act involuntarily. The condition of the pupils varies according to whether the compression is local or general. When local the pupils are unequal as already described and when general the pupils are dilated and fixed, and there is generally oedema of the optic disc and retina.

Laceration. *Localised* laceration of the brain may be caused by a force acting on a circumscribed area, as a blow from a sharp instrument causing fracture with driving in of the inner table.

Diffuse laceration and contusion is most often due to the brain being driven against the skull, when the frontal lobes, which have not the advantage of the arachnoid water bed, suffer most, and, after them, the temporo-sphenoidal lobes. Small *haemorrhages* may occur in the brain substance while larger ones may arise from rupture of the pial vessels or those of the dura. While lacerations frequently involve the cortex and extend into the ventricles, they are sometimes confined to the cerebral substance.

Death is often rapid, but where the patient survives and the injury is chiefly in the frontal lobes, he lies curled up taking no interest in his surroundings, and resents being roused. Urine and faeces are voided automatically.

The pupils are medium and react to light, and there is choked disc, but the patient resists attempts to open the eyes, making examination difficult. Swallowing is easy.

Hernia Cerebri. Hernia Cerebri may develop from bullet wounds of the skull, or where the skull and dura are opened by injury or operation. It may develop immediately where there is intra-cerebral tension, or it may develop after some time, particularly where there is sepsis in the interior.

Intracranial Haemorrhage. Haemorrhage arises most frequently from the middle meningeal artery, or one of its branches, and the symptoms are generally those already indicated—an immediate unconsciousness from concussion, followed by a conscious period, which in turn is followed by unconsciousness, sometimes ushered in with headache, vomiting and drowsiness, and signs of compression, at first often local, but soon general. The condition of the pupils should be carefully noted. Damage to one of the sinuses, particularly the superior longitudinal, may produce similar symptoms. *Subdural haemorrhage* may be due to one of the above causes, where the dura has been torn through, or to damage to one of the pial vessels. The symptoms are often similar to those of the extra-dural type, but this condition is more likely to yield blood stained cerebro-spinal fluid than the former.

Sir William Macewen relates a remarkable case of a man who, in consequence of an injury to the head, had a subdural haemorrhage. The man was not only able to go about, but had a fear of lying down, which made him maintain an upright position for several days after the accident. He at length applied for admission to the Hospital, as he felt that something must be done, and the House Surgeon told him that, particularly as he was a head case, he must lie down. The man explained that he was afraid to do so, but yielded to persuasion. He lay down, and appeared to go to sleep; then his breathing gradually became stertorous, and he died an hour or so

later. On p.m. examination it was found that a clot, which had formed under the dura over the vertex, had slipped down and crushed the pons just above the tentorium.

Meningitis. Various infective processes may arise from fracture, and of these the one most to be feared is *lepto-meningitis*. It may readily arise in any compound fracture of the skull, particularly when due to gunshot wound, and in fractures of the base, communicating with the nose or ear. It may arise within 48 hours of the injury, being ushered in with headache, and perhaps rigor. The temperature becomes high, the pulse small and rapid, respirations rapid. Patient is at first restless and irritable, and soon becomes delirious and unconscious. Irritation of the cranial nerves, often transient, may produce inequality of the pupils, squint, etc. There is generally choked disc. Later the medulla and cord are also involved.

Pachymeningitis, perhaps with the development of an extra-dural abscess, is of less consequence, the patient complaining of a dull headache, while a *Pott's puffy tumour* may develop over the part if the external wound has been allowed to heal, part of the bone generally becoming necrosed at the same time.

Cerebral abscess and sinus thrombosis may also occur as sequelae of fracture with septic infection.

Epilepsy. Jacksonian epilepsy may develop, sometimes from comparatively slight injuries, as, for example, from the continued irritation of a small spicule of bone partially detached from the inner table and projecting inwards in the region of the motor cortex.

Treatment.

Where the fracture is simple and there is no evidence of cerebral implication, there is little to be done. The patient should be kept quietly at rest, a purge should be given, and the diet should be light.

Where the *base is involved*, and cerebro-spinal fluid is escaping from nose or ear, these parts should be regularly

and carefully cleaned out, so as to prevent infection as far as is possible. Syringing should on no account be adopted, as it tends to force septic matter toward the meninges. It is probably better not to pack, lest discharge of blood be prevented thereby, but a dry dressing may be applied over the external ear.

Where the *fracture is depressed*, it is generally advisable to operate and elevate the fragments, or, if the depression be in one piece, it may be necessary to trephine in order to get the portion raised. The portions may then be replaced, and the wound stitched, if aseptic.

Where the *fracture is compound*, immediate operation is desirable. After disinfection with a rapidly acting antiseptic the wound should be excised, and the skull exposed. Detached portions should be removed, cleansed, and placed in warm saline solution, and if portions have been driven through the dura into the brain, these must be sought and removed, in which case it will probably not be wise to close the wound entirely, but to leave in a drain. In more favourable cases the fragments if thoroughly cleansed (by shaving if necessary) may be replaced, and the scalp brought together over them.

Where the fracture is a *simple fissure*, it may be sufficient to disinfect it thoroughly, but sometimes it is engrained with dirt, in which cases the ingrained portions should be shaved off. Punctured fractures should be trephined, as the inner table, and frequently the brain, have been damaged.

Concussion, even when slight, should be treated seriously, and the patient kept quietly in bed for at least a fortnight. Unless this be done he is apt to suffer at a later stage from headache, and incapacity for work. In severe cases warmth should be applied, by electric cage if available. Warm saline enemata should be administered, and warm drinks may be given if the patient can swallow. Artificial respiration may even be necessary. Stimulants are of doubtful value.

The treatment of *compression* consists in removal of

the cause if this can be diagnosed and located. Most frequently it consists in cutting down on the middle meningeal artery, ligaturing the bleeding point, and removing the effused blood. Where the superior longitudinal sinus has been torn, bleeding, which is often very free, may generally be controlled by exposure of the injured part and application of pressure. It should be remembered that a *sinus cannot be picked up by forceps* like an ordinary vessel. If a ligature is required it should be passed through the dura on one side, then through the falx underneath, and then up on the other side through the dura to the surface, a curved bowel needle being used for the purpose. Generally also it is best to tighten the ligature over a pledgelet of gauze placed over the surface of the sinus.

In all cases where there is severe damage to the brain—be it compression, laceration, or contusion—the patient should be kept as quiet as possible; the bladder should be carefully attended to, and, unless there be fear of abdominal injury as well, a sharp purge should be administered. The best is generally croton oil (dose of one to three minims according to strength) embedded in a little butter on the end of a spoon, from which it is transferred to the back of patient's tongue which may be pulled forward for the purpose. It should be remembered in this connection that a patient with a fracture of the base may frequently swallow blood from nose or ear, and vomit it later, thus giving rise to unfounded fear of abdominal injury.

The possibility of a dental plate being broken at time of injury and the fragments falling back and suffocating patient should also be kept in mind.

Vertebrae.

The majority of fractures of the spine are really fracture dislocations, and these are the more important, involving, as they often do, the cord. Occasionally, however, one or more vertebrae may be injured independently.

The *Bodies* of one or more vertebrae may be crushed by indirect violence, applied, perhaps to the shoulders, causing hyperflexion, while the ligaments uniting spines and laminae are torn. The lesion occurs most frequently in the dorso-lumbar region. An angular deformity results which is acute when one vertebra alone is involved, and is more or less rounded when several are affected. The cord generally escapes injury.

Fractures of the *spine or arches* are generally due to direct violence, those of the arches occurring generally in the upper part of the column, and particularly in the cervical region. In unilateral fracture of the arch, the cord generally escapes, but when the injury is bilateral the arch may be displaced forwards and compress the cord. The symptoms are often slight—a feeling of stiff neck, perhaps—and yet a sudden movement may cause death. A *transverse process* may be fractured by direct violence or muscular action. This occurs most frequently in the lumbar region, and gives rise to considerable pain which is increased on rotation or flexion of the spine. Diagnosis may be confirmed by skiagraph. Attempts to elicit crepitus should not be made.

Treatment, where the parts are in good position, may consist of the application of a plaster of paris casing to keep the parts absolutely at rest. In other cases extension should be applied from the head and pelvis, but attempts should not be made to undo deformity by manipulation, where an angular curve exists.

Special *head extension* apparatus is sold, but an efficient method is to apply a broad band of webbing round the head, which is first padded with lint, from under the occiput, above the ears to the brow. The two ends of a loop of similar material are stitched to the band where it passes the ears, and to this loop a cord is attached which runs over a pulley at the head of the bed to a weight. Similarly a firm binder may be applied to the pelvis from the centre of which, posteriorly, a cord runs to a pulley at the foot of the bed. The weights

should be sufficient to keep the patient at rest in extension. Where there are symptoms of compression of the cord, *laminectomy* may require to be performed.

The *cord may be compressed* by effusion of blood either extra or intradurally, or blood may be effused into the substance of the cord (*haematomyelia*) without a fracture or dislocation of the spine being necessarily present. This occurs most frequently in the lower cervical and upper dorsal regions from hyper-extension or flexion due, in a number of cases, to throwing the head back to avoid contact with the bottom in diving.

Fracture Dislocations of the spine are generally caused by severe indirect violence, such as a fall on the head or shoulders, causing hyperflexion, the cervical and upper dorsal regions being most frequently affected.

The fracture of the body affected is generally oblique, from above and behind, downwards and forwards, while, posteriorly, the articular processes are fractured, or the intervertebral ligaments are torn. The whole upper segment of the spine now slides forwards and downwards on the lower segment, crushes the cord as it does so, and, tearing the venous plexus which surrounds it, causes extravasation of blood. The displacement of the column may persist, but not infrequently it immediately regains its position leaving no apparent deformity.

The *symptoms* depend largely upon the injury to the cord, its extent, and the level at which it has occurred. Where the patient survives there may at first be a transient concussion. Deformity may or may not be present, and when present in the regions of the cervical or lumbar curves may show only as a slight flattening of the curves. Contusion of the parts is generally marked, and careful palpation of the spines posteriorly will probably reveal the point of injury by a break in their continuity. The bodies may also be palpated to some extent through the pharynx or side of neck in the cervical region, and through the abdomen for the lumbar region.

In the majority of cases the *lesion of the cord* is complete, but occasionally nerve roots alone may be affected, or a part only of the cord.

Where *nerve roots only* are affected, the sensory phenomena are more prominent, and motor paresis may be temporary. Where the *cord itself* is partially involved, motor phenomena generally predominate. Paresis extends to the whole of the motor area below the seat of lesion, and is generally more marked on one side. The paresis may develop slowly, the lower limbs being more affected than the upper, and it often improves rapidly. Vaso-motor disturbances accompany the paresis. Sensory disturbance may be absent; is generally incomplete when present; does not reach the same level as the motor, and affects various senses unequally. There is generally interference with or loss of control of bladder and rectum, and priapism may be present at first. The prognosis is comparatively favourable.

In considering the effects to be expected from a COMPLETE LESION at a particular level of the spine, it must be remembered that owing to the greater growth of the column in length the cord is ultimately distinctly shorter than the column and therefore its segments do not correspond with the segments of the spine, and many spinal nerves arise a considerable distance above their point of emergence. Thus a nerve belonging to a higher segment may be injured by damage to a lower segment and give rise to what would at first sight appear to be a mixed lesion.

The cervical enlargement is most prominent opposite the sixth cervical, and the dorsal enlargement opposite the twelfth dorsal. The cord generally ends about the lower border of the first lumbar vertebra, but varies somewhat, and the meninges extends to the second portion of the sacrum below which point cerebro-spinal fluid rarely extends.

In gross damage to the *first three cervical vertebrae* death is generally instantaneous. In some cases, however, death may be postponed for hours or days.

All parts below the head are generally paralysed, and even where the phrenic nerve is not destroyed at the time of injury it is generally pressed on by the accumulation of blood in a short period, death occurring from asphyxia. A case of fracture of odontoid process and both arches of atlas however is on record where patient walked for two hours after accident, became paralysed next day and died suddenly on the eighth day.

Where the damage occurs about the level of the *fourth cervical vertebra* the breathing is entirely diaphragmatic, and the intercostal spaces are bulged out on expiration and sucked in on inspiration. Hiccough is generally persistent and vomiting frequent. Violent jerkings occur in the limbs, followed by the *benediction attitude* of the arms, which become rigid, pain being caused by attempts to straighten them. Sensation is retained above the second intercostal space from the supra-clavicular nerves supplied from the fourth cervical segment. There is an absolute paralysis of the reminder of the body, both motor and sensory. The pupils are contracted, and there is recession of the eyeball, with narrowing of the palpebral fissure from paralysis of the cervical sympathetic. Priapism occurs and there is first retention, followed by overflow of urine which sometimes contains sugar. There is incontinence of faeces.

The pulse is slow and full, and the temperature is often high. Death generally occurs within one or two weeks from respiratory difficulty. As the intercostals are paralysed coughing is impossible and mucus accumulates, and hypostatic congestion occurs. There is also a tympanitic distension of the abdomen, and this impedes diaphragmatic respiration.

Between the *fifth cervical and second dorsal*—over the area of the cervical enlargement—the symptoms are very similar to the above. All the intrinsic muscles of the arm are paralysed in a lesion about the fifth cervical except the deltoid, spinati, biceps, brachialis, and supinators of the forearm. The upper limbs are abducted

PLATE VII.

(1) Fracture dislocation of spine with detachment of a fragment of bone which is impinging on, and crushing cord.

(2) Fracture dislocation of the 5th cervical vertebra.

and rotated out at the shoulder, and the forearms flexed and supinated. Where the lesion is slightly lower down—about the sixth cervical—the triceps and pronators of the forearm escape, and the patient can extend the elbow and pronate the hand, and the arms generally lie folded across the chest.

Between the *second and tenth dorsal vertebrae* the breathing is diaphragmatic unless the lesion be below the sixth dorsal. There is a motor and sensory paralysis of the abdomen and lower limbs, and in the lower thorax when the lesion is at the upper extremity of this section. The upper extremity of the anaesthesia runs horizontally round the body, and not parallel to the intercostal nerves, and there is generally a zone of hyperaesthesia at its upper extremity, the patient also frequently complaining of a sensation of something being tightly tied round the body at this level—a girdle pain.

Respiratory embarrassment, and abdominal distension are also liable to occur, these symptoms, however, being less marked than in the previous section.

There may be incontinence of urine, or the bladder may fill and automatically empty from the centre being intact. Priapism is generally present when the lesion is toward the upper end of the section.

In this form the patient may survive for months or years if lung complications be avoided, septic infection of the bladder prevented, and bed sores guarded against. These conditions, however, are liable to occur in spite of care and sometimes death may supervene from ascending myelitis of the cord.

The lumbar, sacral, and coccygeal nerves arise between the positions of the *eleventh dorsal and first lumbar* vertebrae. As their controlling centres are frequently damaged there is generally true incontinence of urine and faeces, and septic infection of the bladder and urinary tract, and trophic changes, including pressure sores, may readily develop. Priapism is absent, and in some cases subsequent control of the bladder may be established.

A complete transverse lesion about the level of the *twelfth dorsal vertebra*, and involving the second lumbar segment, produces complete paraplegia and complete anaesthesia of the lower limbs, including the buttocks and testicles. There is also loss of the knee jerk. *Below that level* some of the muscles of the lower limbs may escape, and while the knee jerk may be absent, it is often only diminished. The testicles are sensitive.

Marked displacement does not readily occur in the *lumbar region* owing to the size and strength of the vertebrae, and the cords of the cauda equina are more resistant than is the cord itself. Hence injuries in this region are often partial.

The upper limit of the area of anaesthesia affords a *guide to the level of the lesion* in the cord, in case of doubt.

A line drawn across the second intercostal space in front, thence across the shoulders a short distance below the acromion, and so to the spine of the seventh cervical vertebrae indicates the upper level of anaesthesia in all transverse lesions from the fifth cervical to the second dorsal segments. A small triangular area between the fifth and seventh cervical spines is affected only by lesions of the fifth, sixth, and seventh cervical segments.

A line drawn across the body at level of nipples runs between the upper limits of anaesthesia of the fourth and fifth dorsal segments: one through the tip of the xiphoid between the sixth and seventh dorsal segments. A line through the umbilicus to the first lumbar spine corresponds to the tenth dorsal segment.

The *level of a spinal segment in relation to the spines of the vertebrae* may be roughly arrived at by subtracting one from the number of the segment in the cervical region; subtracting two in the upper, and three in the lower dorsal region. Thus the fifth dorsal segment lies approximately on a level with the spine of the third dorsal vertebra. The tip of the eleventh dorsal vertebra is opposite the lumbar segments, and that of the twelfth opposite the sacral segments.

The *prognosis* in spinal lesions, as in those of the head, depends chiefly upon the extent of injury to the nerve tissues. Where the cord escapes entirely the prognosis is favourable, although the possibility of late involvement from callus must not be forgotten. Where the lesion of the cord is transverse and high up, the prognosis is hopeless; where it is at lower levels and incomplete there is hope of at least partial recovery.

Treatment. In cases where the lesion is not complete, the question of laminectomy may require consideration if there be signs of compression. This may require to be done at an early stage if there be progressive compression due to haemorrhage, but in other cases it is generally best to wait until natural improvement has been completed. In most cases of fracture dislocation, the prognosis being hopeless, it only remains to make the patient as comfortable as possible. A water bed should be provided to distribute pressure as far as possible, and several layers of blanket should be placed between patient and rubber to prevent accumulation of moisture which favours formation of bed-sores. With the same object in view the skin over sacrum, shoulders, and other prominent parts should be regularly and frequently washed with methylated spirits. The bladder requires careful attention. Sometimes it can be satisfactorily emptied by pressure above the pubes, without introducing a catheter, and if this can be done the risk of sepsis is lessened. Some recommend the making of an immediate perineal section through the anaesthetic tissues as the best method of avoiding cystitis.

Where, on admission, there is a distinct dislocation of the spine it is generally desirable to attempt its reduction by means of extension and counter extension. Where this is not sufficient the patient may be laid on a plank; his shoulders fixed to one end by means of loops of wool or flannel bandage under the axillae and then plank and patient raised so that patient tends to slide to lower end. Gentle manipulation may now reduce the defor.

mity, and hyperextension is easily produced by bending the plank (if required). A moist plaster jacket may be slipped in to position and brought round to the front and fixed and allowed to harden while patient is kept extended.

Sacrum. Fractures of the sacrum alone, apart from the pelvis, are not common. Vertical fractures, through the lateral mass, generally occur from indirect violence, the pelvis being fractured anteriorly at the same time. Paralysis in parts supplied by the sciatic nerve may follow from secondary implication of the roots.

Transverse fracture from severe direct violence is rare, generally occurs at the third piece, and, if the fracture be compound, may possibly lead to meningitis.

The Coccyx is generally fractured by direct violence; the fracture is transverse, and causes considerable pain, which is increased by coughing, defaecation, and other movements, giving rise to coccydynia, for which early excision is probably the best treatment.

Bones of Face.

Nasal Bone. The most common fracture is that which occurs near the free margin of the bone. Fracture is generally bilateral; and compound, from wounding of mucous membrane. The vomer is often fractured in addition. The cause is direct violence.

Direction of displacement is inwards or lateral.

There is generally deformity, but sometimes it is slight, and, after a time, is masked by swelling. Preternatural mobility and crepitus may be elicited. Haemorrhage from the nose may be profuse; emphysema of eyelids and face may be produced on attempting to blow the nose.

The ethmoid and crista galli may be fractured, and the base of skull involved, with possibility of cerebral complication. The lachrymal duct may also be involved.

Treatment. If deformity be present it should immediately be reduced. Dressing forceps may be used, if necessary, to lever out the depressed bone. There is little tendency to recurrence of deformity, and any tendency in this direction may be overcome by a plug of antiseptic gauze or rubber tube in the nose, for a short time. Any plug used must be frequently changed and kept scrupulously clean.

Healing is said to be complete in a week.

Old fracture deformity may be corrected by plastic operation or subcutaneous injection of paraffin wax.

Malar Bone is not frequently fractured, and only as the result of direct violence. The fracture is depressed, and may be compound if Antrum of Highmore be involved. Deformity is generally marked, but may be masked by swelling. In such cases irregularity of inferior orbital margin may be palpated. Subconjunctival haemorrhage may occur, and, if Antrum Highmori be involved, nasal haemorrhage and subcutaneous emphysema may occur. *Zygomatic arch* may be fractured by direct violence, fragments being pushed inwards and presenting hollow to outer side and below eye; while movement of jaw may be limited (from interference with masseter muscle or coronoid process).

Treatment. Immediate correction of deformity by manipulation, assisted, if necessary, by introduction of instrument through cheek to lever up lower margin of bone.

Superior Maxilla is generally fractured by direct violence, and fracture is compound, communicating with either mouth or nose. Fracture may involve alveolar process, generally as result of tooth extraction. Fractures of the body may be vertical or horizontal, both bones being sometimes involved, or they may be comminuted, as in the case of gunshot injury.

Preternatural mobility and crepitus may be elicited. Haemorrhage and salivation, and emphysema of the cheek may be present, and also irregularity and looseness

of some of the teeth. The infra-orbital nerve may be involved with consequent neuralgia or anaesthesia.

Treatment. Reduce any deformity present. Keep nose and mouth clean. Apply a four-tailed bandage over lower jaw, thereby steadying parts. An interdental splint applied to upper jaw may serve to keep parts steady in apposition. As a rule loose teeth should not be extracted as they may bring away useful pieces of bone with them and in any case they tend to firm up again.

Lower Jaw.

The most common fracture is that which occurs **near the mental foramen,** the jaw being weakened at this part by the presence of the foramen, and the socket of the canine tooth. Fractures about this situation are nearly always compound owing to tearing of the mucous membrane of the gum, and are frequently bilateral. Fracture occurs less frequently in *middle line.* The cause may be either direct or indirect violence, generally a blow or fall on the jaw at the point of fracture or on the chin.

The *line of fracture* is oblique from without inwards and may be vertical from above downwards or run backwards toward the angle. When the fracture is at middle line *displacement* is slight: when it is further out the anterior fragment tends to be displaced downwards and backwards, either in front of or behind the posterior fragment according to the obliquity of the fracture, by the weight of the jaw assisted by the digastric genio-hyoid, genio-hyo-glossus and mylo-hyoid. The latter muscle being attached to both fragments tends to minimise the displacement. The posterior fragment maintains its position or is drawn slightly upwards by the masseter. (Where the fracture is bilateral the central portion is depressed and drawn backwards by the genio-hyoids, and the tongue may tend to fall back also.)

The slight deformity is often concealed by swelling. Preternatural mobility and crepitus can generally be elicited. Haemorrhage and salivation occur, and the

jaw is often supported by the hand to limit movement, which is painful. There is irregularity in the line of the teeth and one or more may be loose. Tearing of the mucous membrane may be observed, and sometimes the inferior dental nerve may be torn.

The chief *danger* is sepsis in the compound varieties. Difficulty in obtaining proper alignment may be due to

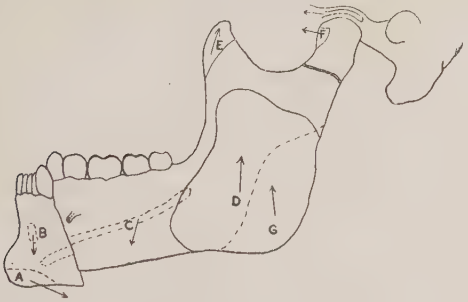


FIG. 6.

Diagram of fractures of jaw.

Insertions of muscles on deep surface of bone are shown by dotted lines.
Fracture of ramus about mental foramen.
Anterior fragment displaced down and backwards by
A Digastric.
B Genio-hyoid and genio-hyo-glossus.
C Mylo-hyoid.
Posterior fragment drawn slightly upwards by
D Masseter.
E Temporal.
G Internal pterygoid.
Fracture of neck of jaw.
Upper fragment drawn up, in and forwards by
F Ext. pterygoid.
Lower fragment drawn up by
D, E, and G.

wedge action of the fang of a tooth and may necessitate its extraction.

Treatment. An *interdental splint* of some kind may be employed. The teeth having been got into alignment, an elongated mass of dentists' modelling composition, softened in hot water, is laid over them and pressed down round them back and front for a considerable distance on either side of the fracture, and is kept in

position until cool, when it may be removed and trimmed, and fitted with a silk thread, a loop from which is placed round the ear to prevent the possibility of the splint being swallowed.

Fine silver *wires* may be passed between the teeth on either side and twisted together, or they may be combined with a thicker wire, if there be sufficient room between the teeth. The thick wire is first placed in position round teeth on either side of fracture and twisted up so as to hold the fragments firmly, and then the thinner wires pass from side to side of the thick wire between the teeth, helping to hold it in position. Where the fracture is compound and an anaesthetic is necessary to effect proper reduction, a hole may be bored on either side of the jaw itself and a *stout silver wire* passed and twisted up. It is generally better, however, to apply an *external poroplastic splint* for ten days until the wound has healed and the mouth has been thoroughly cleaned and then to fix the jaw with two wires one above the other, the operation being performed through an external incision.

In all of these cases the splint or wire should be supplemented by a four-tailed bandage applied as described later, for about a week.

An *external splint of poroplastic* is fairly efficient when properly made and applied if there be no great tendency toward recurrence of displacement.

A piece of poroplastic is cut of strictly rectangular shape, the length being that from ear to ear over the tip of the chin, and the breadth that from margin of the red lip to pomum Adami. A vertical line is drawn down the centre of this piece, and the position of the chin marked on it. At the level of the chin a horizontal line is drawn. A cut is now made along this horizontal line on both sides extending to an inch from the middle line, and these cuts should be slightly V shaped. A depression should also be cut on the under surface to prevent pressure on the pomum Adami. The poro-

plastic is now softened by heat either of fire or water, and is moulded into shape by bringing the ends over one another, while the portion to go under the chin is pushed upwards, so that a gutter is formed in which the jaw bone lodges. When cool and hard the splint is trimmed; the ends may be fixed by piercing them and then inserting a paper fastener or tying with tape, and it is padded with a piece of lint folded on itself, the folded edge being allowed to project very slightly above the splint where it comes opposite the lip.

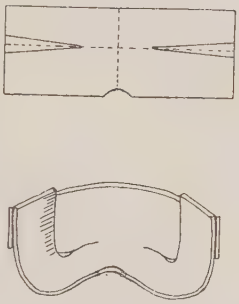


Fig. 7.

Poroplastic splint for lower jaw. Note how centre of under surface is pushed up to form a gutter for the jaw at periphery.

The splint is now applied and fixed by means of a four-tailed bandage. A pad of lint, of elongated shape, is placed on the head, extending from the forehead to the neck. The two lower tails are brought up in front of the ears, and tied firmly over the anterior end of the lint. Before fixing these ties, inspection should be made to ensure that the teeth are firmly clenched. The two upper tails are carried back to the nape of the neck, where they also are tied over the lint, and lastly, the free ends of the two sets of tails are brought together and tied, to prevent slipping forwards or backwards.

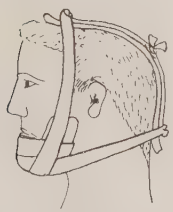


Fig. 8.

If all goes well, the splint may generally be removed after four weeks Meantime the patient is fed on liquids and soft food and the mouth must be kept as clean as possible, dilute tincture of iodine being one of the best preparations for this purpose, either swabbed over the gums, or added to water with which the mouth is rinsed. Where an

interdental or wire splint is used, gentle mastication may be begun after about three weeks.

Fracture of the ramus behind the teeth is rare, and may be vertical, or oblique downwards and backwards.

Fracture of the neck of the condyle is generally due to indirect violence applied to the chin. There is pain on movement of the jaw, which inclines very slightly to the injured side. The *coronoid* may be fractured by direct violence. Fracture of the *ascending ramus* is not common, is generally due to direct violence, may be transverse, and is sometimes bilateral. Fracture of the *alveolar margin* sometimes occurs in extracting a difficult tooth, a small portion of the bone becoming detached. These fractures may be treated by the poroplastic splint and four-tailed bandage. In some cases where the condyle of the jaw has been involved it may be necessary to excise it.

Hyoid Bone is most frequently fractured by indirect violence due to compression of the throat, the fracture occurring at the junction of body and great cornu. It may also be fractured by direct violence, and possibly by muscular action. The fracture may be compound from tearing of the pharyngeal mucous membrane by one of the fragments. Crepitus is not easily elicited. There is great pain on movement, especially of the tongue, and swallowing is much interfered with. There is generally considerable swelling, which may be obvious externally. Where the fracture is compound, bleeding may occur from the mouth, breathing is interfered with and oedema of the glottis is apt to supervene.

Treatment. Reduction of the displacement, with one finger working from the base of the tongue, is not easy, and retention of position difficult to obtain.

It is generally wise to perform *immediate tracheotomy* and patient will probably require to be fed by stomach tube for some time.

Thyroid cartilage may be fractured, particularly in older persons in whom the cartilages are ossified, by

same causes as hyoid bone. The fracture is generally compound. Undue mobility can sometimes be detected and also irregularity of outline, unless masked by swelling. Difficulty in respiration may come on immediately from submucous effusion of blood, or later from oedema. Frequent attempts are made to swallow which cause great pain. There is cough with blood in sputum.

Treatment. Perform immediate tracheotomy, and then attempt to correct displacement.

Clavicle.

The clavicle is more frequently fractured than any other bone in the body except the radius. This is due to its exposed position; its receiving a large part of all shocks communicated to the arm, and to its ossifying early. It forms in membrane; begins to ossify about the sixth week of foetal life, and the entire shaft is bony at birth. Thus fracture may occur during intra-uterine life and at birth. It occurs frequently in childhood, and in adolescence, the sexes being equally affected. In adult life it occurs more frequently in males.

Fracture may be due to direct or indirect violence, or muscular action. The common *cause* is indirect violence, particularly falls on the outstretched hand or on the shoulder.

The fracture most often occurs at the **junction of the middle and outer thirds**, the line of fracture being oblique from above, downwards and inwards. In children the line is more generally transverse.

Displacement. The inner fragment maintains its position or its outer end is slightly raised by the clavicular portion of the sterno-mastoid. The outer fragment undergoes displacement in three directions. (1) Downwards by weight of arm, pectorals, and latissimus dorsi. (2) Inwards towards body by pectorals, latissimus dorsi, trapezius, rhomboids, and levator anguli scapulae. (3) Rotation on a vertical axis so that the acromial end is

displaced forwards and inwards while the broken end instead of looking inwards, looks inwards and backwards. This third displacement is due to the action of the serratus magnus upon the scapula, to the vertebral border of which it is attached. Its action tends to draw the scapula round the chest wall from back to front, the bone turn-

FIG. 92.

Diagram illustrating displacement in fracture of clavicle, viewed from front. A. Serratus magnus.

(1) Before displacement has occurred.

ing in the arc of a circle as it does so. This it would do were it not for the clavicle which, acting as a sort of outrigger, keeps the scapula away from the trunk as it comes forward. When the clavicle is broken the outrigger action disappears, and the outer end of the outer fragment, firmly attached to the acromion, turns forwards and inwards as described. This third displacement is the one most difficult to correct.

Symptoms. Patient generally stands with head inclined to affected side; elbow of affected side supported by sound hand, and forearm of affected side supported by sound forearm. Deformity is generally marked, outer end of inner fragment forming a distinct prominence, which can be palpated even when masked by swelling.

FIG. 9*b*.

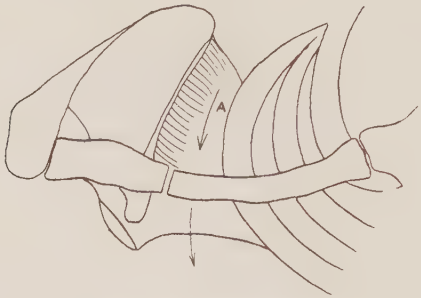
(2) After displacement has occurred. Outer fragment is depressed, displaced inwards, and rotated.

Preternatural mobility and crepitus can generally be easily elicited.

Where fracture occurs in the **region of the coraco-clavicular ligaments** displacement is generally very slight and when it runs between the conoid and trapezoid portions there is no displacement.

When fracture occurs **external to the ligaments**, from a fall on the back of the shoulder generally, the short outer fragment attached to the acromion is drawn forward

and markedly rotated on its vertical axis as before, and is depressed by the weight of the arm, the deformity simulating dislocation of the shoulder, from which it is easily distinguished by the free movements of the shoulder joint.



(1) Before displacement has occurred.

(2) After displacement has occurred.

FIG. 10.

Diagram illustrating displacement in fracture of clavicle viewed from above.
A. Serratus magnus.

Fracture of the inner third is rare and generally due to direct violence, the line of fracture being generally oblique. Displacement may be slight due to the action of the sterno-mastoid on the inner fragment being counteracted by the costo-clavicular ligament. Some-

times the inner end of the outer fragment may be displaced downwards and slightly forwards by action of the subclavius, and simulate dislocation of the inner end of the clavicle. *Separation of the epiphysis* rarely results between the ages of 17 and 25 from severe muscular action. The epiphysis lies within the capsular ligament of the sterno-clavicular joint and is generally easily replaced and retained in position.

The clavicle is a frequent seat of *greenstick fracture*, due perhaps to its early ossification and thick but loosely adherent periosteum. Longitudinal splits may occur, especially in the outer half, and are often difficult of diagnosis. *Bilateral fracture* is uncommon, and is generally due to great violence, particularly a severe blow applied from behind between the shoulders. Fracture from *muscular action*—deltoid and pectoralis major—has occurred in the middle third.

Complications. The fracture is rarely compound. The subclavian vessels, internal jugular vein and acromio-thoracic artery are occasionally damaged, and the cords of the brachial plexus may be injured at the time of fracture, or subsequently involved in callus.

A few cases of injury to pleura and lung have been reported.

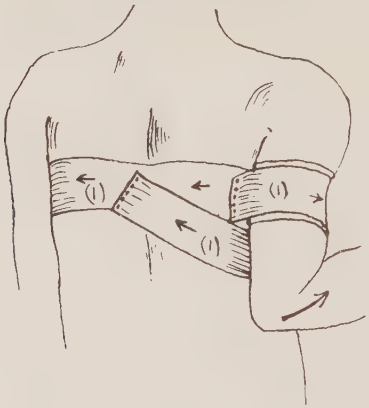
Treatment. Where there is no displacement, the arm should be supported in a sling for three weeks, massage and passive movement being commenced at once.

The common fracture at junction of middle and outer third can generally be successfully treated by means of *Sayre's strapping method.* Only lint and adhesive strapping two and a half inches broad are required. (Zinc oxide should always be used as it does not damage the skin as rubber adhesive does.) The parts should first be well washed with spirit, and if necessary shaved.

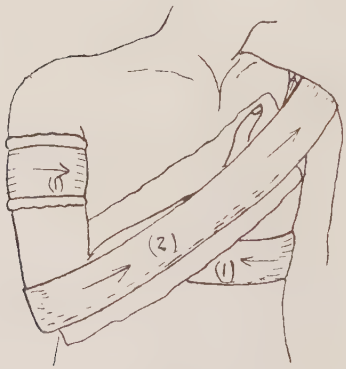
The essentials consist of two strips of lint and two strips of strapping.

(1) Place a piece of lint round upper arm of injured side at level of insertion of deltoid. Take a turn of

adhesive plaster round this, with adhesive surface out, and stitch the free end to the continuation of the plaster. Draw the arm slightly backwards, and then carry the



First strap.



Second strap.

FIG. 11.—Sayre's method for fractured clavicle.

plaster whose adhesive surface is now next the skin, right round the body, from back to front, and so to back again.

(2) Place a piece of lint obliquely across chest in front, and then, pushing elbow forward, place forearm across chest, bringing fingers as far as possible up on to shoulder of sound side. Then take plaster, adhesive side next skin, from sound shoulder, down across back to elbow of injured side, and so up in front along forearm of injured side, and finish by running down over scapula of sound side.

(3) A circle of strapping may be run round body and injured arm, to help to keep it in position, but this is not an essential of the process.

Action (1) fixes middle point of humerus; therefore in whatever horizontal direction elbow moves, head of humerus, carrying with it scapula, and consequently outer end of clavicle, moves in opposite direction.

(2) (*a*) raises elbow thereby correcting downward displacement, (*b*) carries elbow inwards and therefore throws outer fragment outwards, correcting inward displacement, (*c*) carries elbow in arc of circle round chest forward and inwards, and so forces outer fragment in arc of circle in backward and outward direction, thereby correcting the serratus displacement.

As band number two is carried round elbow, and elbow pulled forward by it, the outer fragment of clavicle should be felt to rise into position. The plaster should be kept on the reel, and not cut into strips, as it is much easier to manipulate, and the reel gives a good hold for applying traction. A slit should not be cut in the plaster for tip of elbow, as it is apt to cut the skin, and the plaster should be applied to include the broad surface to inner side of elbow.

Make sure that radial artery is pulsating actively at wrist before patient is allowed to go. A gauze bandage is often applied over the parts to keep them in position until plaster gets a thorough grip. The parts should be regularly inspected and the number two strip re-applied whenever there is sign of slipping. Keep up for three to four weeks, thereafter apply a sling for a short time, while continuing massage and commencing passive move-

ment. The writer has had many excellent results with this method in dispensary work, no appreciable deformity resulting, while in many cases the contour was completely restored.

Occasionally the parts cannot be got thoroughly into position by above method, and then it must be supplemented by other arrangements, or a different method employed. *Supplement.* Roll a little cotton wool in each of a couple of triangular handkerchiefs, and pass the handkerchiefs so padded under each axilla, and up over shoulder; tie posteriorly leaving free ends behind. Then apply the strapping, and while endeavouring to get the outer fragment into position by strap number two, assist the action by bracing the shoulders back by the triangular handkerchiefs, which should be knotted together behind. A good result may sometimes be obtained by the use of the knotted handkerchiefs alone, the elbow being supported in a sling to correct downwards displacement, or the shoulders may be braced back by means of a *straight padded splint* placed across the shoulders posteriorly to which they are strapped, the arm being supported in a sling as before. Massage and passive movement can be commenced at once in either method.

Often the difficulty of the serratus action may be overcome by getting patient to stay in bed even for a few days with a *narrow pillow* placed vertically down between the shoulders. This is sometimes used alone, or in conjunction with the methods described already. If these are not employed the patient should incline somewhat toward the sound side and the elbow of affected side should be raised on a pillow, so as to tend to push the shoulder upwards and backwards.

A better result may possibly be obtained by *applying extension strapping* to the upper and forearm by which arm is held in position of extension and abduction above head by a weight of about twelve pounds for a fully developed man, the cord going over pulley at top of bed. A binder should be placed round chest and pinned to other side

of bed to keep patient in position and provide counter-extension. In this method massage can be begun at once and passive movement after a week.

In fracture beyond the conoid and trapezoid ligaments Sayre's method may be tried, but, if it does not succeed, *operation* with fixation in position by wire or plate may be necessary.

Prognosis is good. The clavicle generally unites and, even if there be some deformity, it does not as a rule prevent use of the arm. Where a projection at seat of fracture is so marked as to cause pain, this may be removed by operation, and in the rare cases where a pseud-arthrosis develops and prevents use of the arm, the ends may be refreshed by operation and fixed in position by wiring or a plate.

Scapula.

Fractures of the scapula, apart from those due to gunshot wounds and similar injuries, are not common, owing to the protection the bone receives from the muscles lying on it; the muscles on which it lies; the elasticity of the chest wall, and its own mobility.

They may be classified as those (1) of the body (2) of the acromion (3) of the coracoid (4) of the surgical neck (5) of the glenoid cavity.

(1) *Fracture of the body* is the most common; is due generally to severe direct violence; may be linear, stellate or comminuted, and may involve the infra-spinous fossa alone, or, traversing the spine, involve the supra-spinous fossa also.

A *haematoma* generally forms over the site of fracture, increasing the difficulty in palpation. Crepitus and preternatural mobility are not easily elicited as a rule.

Treatment. If a large haematoma be present, it should be evacuated with care as to asepsis. The forearm and elbow should be supported in a sling, and a firm body bandage applied over the scapula, including the upper arm, which parts are first padded with cotton wool.

Marked displacement may generally be reduced by extending and abducting the upper arm by extension apparatus, as for fractured clavicle, and then adhesive strapping may be applied over the scapula to try to fix the parts in position. Extension may be removed after three weeks. Massage should begin early and passive movement after a week.

The body of the scapula is frequently comminuted in *shrapnel wounds* of the shoulder, sharp fragments of bone being dispersed amongst the muscles which are extensively lacerated thereby. Where the wounds are septic, and particularly where there is any suspicion of gas gangrene, the track of the foreign body must be laid freely open, and the damaged muscle excised, along with the fragments of bone.

(2) *Acromion.* Fractures of the acromion process are generally caused by severe direct violence, such as falls on the shoulder. In some cases the fracture is probably a separation of the epiphysis which joins the body about the twenty-third year. Displacement is generally slight owing to the dense fibrous covering of the attached muscles.

The shoulder has a tendency to droop and appears slightly flattened. Crepitus may be elicited. Patient cannot raise arm from side.

Treatment. Support elbow in a sling and apply bandage round chest and affected arm. Remove after three weeks. Begin massage of shoulder early and passive movement after a week.

(3) *Coracoid* is rarely fractured, by direct violence, muscular action, or by impact against the clavicle in dislocation of the shoulder. It may also be *separated as an epiphysis* up to about the seventeenth year.

The line of fracture generally runs about an inch behind the apex; displacement is generally slight, the coraco-clavicular ligaments remaining intact, and a skiagraph may be necessary to clear up the diagnosis.

Treatment. Support elbow and forearm in a sling,

PLATE VIII.

(1) Old malunited fracture of clavicle.

(2) "Spontaneous" dislocation of wrist forwards.

(3) Old separation lower epiphysis radius with subsequent arrest of growth and apparent overgrowth of ulna.

(4) Separation of upper epiphysis of humerus.

bringing forearm well across chest, and apply a body bandage. Begin massage at once and passive movement after a week. Remove sling at end of three weeks.

(4) The *surgical neck* of the scapula runs from the supra-scapular notch to the under surface of the glenoid, and therefore includes both coracoid process and glenoid. Fracture, which does not closely follow the anatomical

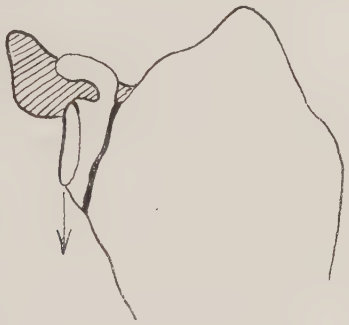


FIG. 12.
Fracture surgical neck of scapula.

neck, is rarely caused by severe direct violence. Generally the coraco-clavicular and coraco-acromial ligaments remain intact and displacement is slight, but when they are torn, the glenoid, carrying with it the coracoid and the entire upper limb, may be displaced downwards, the condition resembling a subglenoid dislocation. From this it may be distinguished by the fact that the deformity is easily reduced by pushing the elbow upwards, but immediately returns when the elbow is released, crepitus sometimes being elicited in axilla while doing so, and further that the coracoid is also displaced.

Treatment similar to that for fracture of the clavicle may be employed—Sayre's strapping, taking care to raise the elbow fully, but not carrying it much forward; or extension and abduction. Massage should be commenced immediately and passive movement after a week.

(5) *Fracture of the glenoid cavity* is uncommon; is caused by falls on the shoulder; is best diagnosed by X-ray, and *treated* by supporting the elbow and forearm in a sling. Massage should begin at once, and passive movement within a week.

Ribs.

Fracture may be due to direct violence, such as a blow, or to indirect violence, such as a crush, or to muscular action as in coughing or straining. One or several ribs may be involved, and sometimes ribs are fractured on both sides of the chest. A rib also may be fractured in more than one place.

Fracture of the ribs occurs most frequently during adult life, particularly in males, and the ribs most frequently affected are the *fifth to the seventh*. The *first* rib, being sheltered by the clavicle, is rarely fractured, but fracture has been caused by the clavicle being driven down upon it. The *second* and *third* ribs are slightly protected by the projection of the clavicle, and by the mass of the pectoral muscles.

The *floating ribs* generally escape fracture on account of their mobility.

Fractures due to *indirect violence* occur most frequently in the region of the angle; they may be oblique or even spiral, and the ends tend to be displaced outwards.

Fractures due to *direct violence* are generally transverse and the ends of the fragments tend to be displaced inwards. Fractures of ribs may be complete or incomplete (greenstick), are rarely compound externally and may be entirely subperiosteal, but they not infrequently cause damage to the intercostal vessels, pleura and even the lung.

Symptoms. There is generally sharp pain at the point of fracture on taking a full breath, and breathing is therefore shallow. The pain is increased by direct pressure on the point, or by antero-posterior pressure on the chest. The pain is sharply localised, and therefore guides one to the point of injury. Crepitus may be detected by

placing a finger on the rib on either side of the point of fracture and making pressure alternately on either side. It may also be elicited by compressing the chest antero posteriorly or asking patient to take a deep breath while the hand is laid flat on the chest wall over the affected area. Crepitus is sometimes absent, and it must not be confounded with the crackling of surgical emphysema, which frequently co-exists.

Complications are generally of more importance than the fracture. When the fractured rib penetrates the pleura and damages the lung, air may be forced on expiration from the lung into the cellular tissues, particularly the subcutaneous tissues, causing *surgical emphysema.* This condition may be localised to the neighbourhood of the injury or may be very extensive, involving the neck and face on the one hand, and the abdomen and scrotum on the other. When the scrotum is affected it may become greatly distended, resembling a large double hydrocele. Less often the emphysema may extend down the limbs to the fingers or toes. In some cases air may gain entrance into the lung substance direct and spread thence to the root of the lung and so to other structures.

Where the rib, in penetrating the pleura, tears a flap of visceral pleura which acts as a valve, air may be forced on expiration between the layers of the pleura, destroying the *force of cohesion* * by which they are normally kept together, and giving rise to *pneumothorax.* This condition tends to be progressive, and, if not attended to promptly, causes intense difficulty in respiration, with cyanosis and tendency to cardiac failure and collapse. The treatment is very simple, all that is necessary being

* Sir William Macewen has demonstrated by means of two pieces of optically worked glass adhering to one another by means of water between the worked surfaces and placed in the receiver of an air pump that the adhesive force is cohesion, and is not atmospheric pressure as is generally taught. A weight almost sufficient to pull the pieces apart in the open air will not succeed in doing so when atmospheric pressure has been reduced as far as the mercury air pump can reduce it.

to let the air out by introducing a trocar and cannula into the pleura and then compressing the chest wall so as to extrude the air and re-establish the cohesion; or a small incision may be made for the same purpose. The pleural opening should not be closed until the valve wound has healed and ceased to act as such. In somewhat similar manner blood from the injured intercostal vessels or lung may find its way between the layers of the pleura, causing *haemothorax*, while, if pyogenic organisms gain access a *pleurisy* or *pyothorax* may be set up.

Injury to the lung may cause haemoptysis, and bronchitis or pneumonia may supervene upon infection.

Treatment is to strap the chest wall when one side only is affected, the idea being to limit movement on the affected side. In uncomplicated cases it generally affords great and immediate relief, and it should always be applied as soon after the injury as possible as it tends to prevent or limit the extension of complications.

Zinc oxide plaster in reels, about two or two and a half inches wide is very suitable for the purpose. The patient should clasp the hands above the head, and then, beginning either above or below, a strip should be run direct from the reel from beyond the spine behind to beyond the sternum in front, in the line of the ribs, during expiration. The reel enables the plaster to be pulled tight during application, which is an important point. A second strip is then applied in the same manner, overlapping the first for about one third of its breadth, and so on until the side is covered. A vertical strip may be applied along spine and sternum, if necessary, to fix the ends, and if the patient is not in bed, it is generally well to apply a light gauze bandage round the chest to prevent the plaster being detached by the clothes before it becomes thoroughly adherent. This bandage should not be applied tightly, and may be removed after a few hours. The strapping should be kept on for three weeks.

Surgical emphysema does not generally call for special treatment and may frequently be prevented by early

application of the strapping. The treatment of pneumothorax has already been given. Haemothorax should be aspirated if extensive and causing respiratory difficulty, as should pyothorax, the latter generally necessitating excision of part of a rib.

All cases with complication should be kept in bed, an upright position often being most agreeable. Pain may be alleviated by morphia, and respiratory difficulty by inhalation of oxygen. Bronchitis may require the administration of expectorants.

The **Costal Cartilages** are occasionally fractured, more especially in old persons where the cartilages have undergone ossification, as the result of direct or indirect violence. The condition is sometimes associated with fracture of the corresponding rib posteriorly. The line of fracture is generally transverse and clean cut.

The symptoms and treatment are similar to those of fractured ribs.

Hernia of the lung is a condition which rarely follows upon fracture of a costal cartilage, while a diffuse bulging is occasionally met with after fracture of several ribs. In cases of severe crushing of the chest, with or without fracture of the ribs, as may be caused by squeezing between railway buffers, "*traumatic asphyxia*" may be produced. The condition develops instantaneously, as observed by Sir William Macewen in an actual accident at which he was present, and consists of a cyanosis of the face, neck and chest due to multiple punctiform ecchymoses. The conjunctivae are also involved but are generally bright red in colour, and the condition also affects the brain, lungs and pleurae and perhaps other internal organs, as it may likewise affect a large portion of the surface of the body, besides the face, neck, and chest.

Fractures of the **sternum** are rare; are most often due to indirect violence such as acute flexion or extension of the trunk, but may be due to direct violence or even muscular action; are generally transverse, and occur most frequently at the junction of manubrium and

gladiolus. When displacement occurs the lower fragment generally overlaps the upper.

Fractures of the sternum are frequently *complicated* by extensive injury involving the thoracic and abdominal viscera. Where the periosteum on the posterior surface is torn and particularly when the internal mammary vessels are injured, rapid effusion of blood into the mediastinum may cause pressure on the heart and death.

Where there is no displacement, *treatment* consists in rest in bed; where there is displacement, attempts may be made to keep the parts in position after rectification, which is generally easy, by placing a pillow under the back so as to put the sternum on the stretch. Operative measures have sometimes been employed. In many cases the complications are clamant, the fracture being of secondary importance.

Humerus.

Fractures of the humerus may be considered in three sections (1) Fractures of the upper extremity (2) Fractures of the shaft (3) Fractures of the lower extremity. (1) Includes fractures of the anatomical neck; through the tubercles; separation of upper epiphysis; surgical neck. (2) Includes fractures above and below the insertion of the deltoid and (3) transverse supracondyloid; separation of lower epiphysis, and fractures about joint.

Fractures of the Upper Extremity.

A few cases of fissured *fractures of the head* are on record.

Anatomical neck: Intracapsular. This fracture occurs most often in elderly persons as the results of severe direct violence, and is not common. The line of fracture follows the anatomical neck more or less completely, and displacement and deformity are generally slight. Impaction may occur, the small head being impacted into the large surface of the tuberosity.

Symptoms. There is pain, markedly increased by raising and slightly abducting the elbow, whereby the

fractured surfaces are brought into contact; loss of function, and slight flattening of the shoulder. Later there may be discoloration. Crepitus may not be obtainable, but sometimes the upper end of the lower

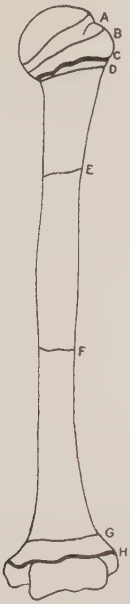


FIG. 13.—Fractures of the Humerus.

A Anatomical neck.
B Through the tubercles.
C Upper epiphysis.
D Surgical neck.
E Shaft above insertion of deltoid.
F „ below „ „ „
G Transverse supra condyloid. „
H Lower epiphysis.

fragment may be palpated projecting inwards and slightly forwards, and simulating a subcoracoid dislocation.

Treatment. Where there is *no impaction* the head is almost entirely deprived of blood and often dies, becoming practically a foreign body. If patient's health permits, an operation may be performed and the head fixed in position if vitality is satisfactory or perhaps it is better

removed. If operation cannot be performed the limb may be extended at right angles to the trunk by extension apparatus, patient being propped up in bed to prevent hypostatic congestion. Massage should begin at once, passive movement after two weeks, and the extension removed at the end of three weeks.

Where there *is impaction*, support the elbow and forearm in a sling for three weeks, begin massage at once and passive movement after a week.

Fracture through the tubercles: Extra-capsular. This is generally due to severe direct violence, and, as the bone surfaces are broad and the fracture takes place through muscular insertions, displacement is generally slight. Sometimes partial impaction takes place.

Treatment by Middeldorpf Triangle (q.v.). Operation may rarely be necessary to correct displacement.

Fracture of the great tuberosity may be caused by direct violence driving the tuberosity into the cancellous tissue of the upper end of the bone, or the upper part of the process may be torn off by the muscular action of the spinati muscles. This latter condition may occur as a complication of a dislocation, but even when dislocation does not occur, there is generally a degree of forward subluxation of the head.

Fracture of the small tuberosity is rare.

The *treatment* of fractures of the tuberosities, when the parts maintain their positions, is to support the elbow and forearm in a sling, massage and passive movement being given from the outset. Where there is displacement it may be necessary to operate and fix the fragment in position.

Separation of the upper epiphysis occurs most frequently between the ages of nine and seventeen, particularly in males; generally affects the left side, and may be caused by direct violence or by falls on the elbow.

Symptoms. As the surfaces are broad there may be little displacement, but not infrequently the upper end of the lower fragment is displaced inwards and forwards,

the appearance presented somewhat resembling a subcoracoid dislocation. From this it may be distinguished by the head being in its proper position; crepitus, which, however, is very soft; and the presence frequently of a groove in the skin extending from below acromion toward axilla caused by the skin being caught by the projecting upper end of the lower fragment. The deformity is temporarily removed by applying traction.

Union generally occurs readily, but movement and growth may be defective unless good apposition is obtained.

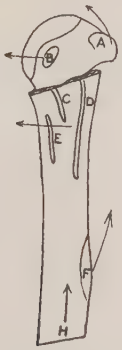


FIG. 14.

Fracture of Surgical neck of Humerus. Upper Fragment abducted and rotated outwards by A supra and infra spinati and teres minor, counteracted to some extent by B subscapularis. Lower Fragment drawn up by H representing biceps and triceps, and by F deltoid (which also throws elbow outwards) and drawn in by D pectoralis major, C latissimus dorsi and E teres major.

Treatment. Where there is no deformity, support the wrist in a sling and begin massage and passive movement at once. Where there is deformity and this cannot be corrected by splint, or extension with full abduction (elbow close to head), operation is necessary.

Surgical Neck. The surgical neck is defined as being below the tuberosities but above the insertions of pectoralis major and latissimus dorsi. The cause is generally direct violence; sometimes falls on the abducted elbow

or hand, or muscular action. The line of fracture is generally transverse, and there may be little displacement, but the force which causes fracture tends to displace the upper end of the lower fragment inwards, the elbow being abducted in consequence.

Further, muscular action also comes into play, the upper fragment being abducted and rotated outwards by the supra- and infra-spinati and teres minor, inserted into the great tuberosity (this action being, however, counteracted to some extent by the action of the subscapularis inserted into the lesser tuberosity) while the lower fragment is drawn up, in, and forwards by the pectoralis major, latissimus dorsi, teres major, biceps, coraco-brachialis and triceps, and also by the deltoid, which at the same time throws the elbow obliquely outwards.

Symptoms. The elbow is therefore thrown both outwards and backwards. There may be flattening over the insertion of the deltoid and a furrow running up from axilla toward acromion. The upper arm is shortened. The lower fragment is sometimes impacted into the upper.

The condition may resemble dislocation but may be distinguished by the head being in position; palpation of sharp upper end of lower fragment in axilla, and free external rotation being permitted.

Treatment. When parts are impacted in good position, apply sling to wrist, pad and bandage arm to side, and begin massage and passive movement at once. Where there is deformity, such as marked abduction of the upper fragment, manipulation under anaesthetic may be necessary, and then the limb may be put up in a Middeldorpf Triangle (q.v.). Extension with abduction over a pulley at the side, or better, at the head of the bed, may also be employed. A weight of about fourteen pounds is required for an adult, and it should be kept up for four weeks, massage being given at once and passive movement after ten days. If angularity still persists a lateral extension at right angles, with a band passing over the

apex of the angle will assist. If this does not succeed then operation and plating may be necessary, the bone being exposed by an incision between deltoid and pectorals.

Fractures of the Shaft.

Above the insertion of the deltoid. The cause is generally direct violence, but may be indirect or muscular. The line of fracture may be transverse, spiral or oblique. The upper fragment tends to be drawn inwards by the

Fig. 15.—Fracture of Shaft of Humerus above insertion of deltoid.
Upper fragment is drawn inward by C latissimus dorsi; D pectoralis major; E teres major.
Lower fragment is drawn up by H biceps and triceps and its upper extremity outwards by F deltoid; G is coraco brachialis.

pectoralis major, latissimus dorsi, and teres major, while the lower fragment is drawn upwards by the biceps and triceps, and its upper extremity outwards by the deltoid.

Below the insertion of the deltoid. This fracture is more common than the former and the causes are the same. The displacement is often slight where the

fracture is transverse, but where it is spiral or oblique and the obliquity favours the displacement, the upper fragment is abducted by the deltoid, counteracted, however, to some extent by the muscles inserted into bicipital groove, and the lower fragment is drawn up by the biceps and triceps, its upper extremity being thrown slightly inwards, generally by the fracturing force.

FIG. 16.—Fracture of Shaft of Humerus below insertion of deltoid.
Upper fragment is abducted by F deltoid.
Lower fragment drawn up by H biceps and triceps.

Complications include involvement of the vessels or nerves of the arm, the musculo-spiral being particularly liable to implication either at the time of the accident or subsequently from stretching or involvement in callus. *Non-union* is said to occur particularly frequently in the shaft of the humerus, a false joint forming, due possibly to the interposition of soft tissues, but much more probably to method of treatment adopted, movement often being permitted by splints resting against the chest wall instead of the pelvis.

Symptoms. The limb is shortened as measured from the acromion to the external epicondyle. Preternatural mobility and crepitus are easily elicited. Where crepitus is not distinct it is generally an indication that soft tissue is intervening between the fragments, which of course would tend to produce non-union.

Treatment by Middeldorpf Triangle, (q.v.) or by extension, with abduction over a pulley at the side, or better, the head of the bed, with lateral pulls if necessary. A weight, of about fourteen pounds for an adult, is applied for about four weeks, massage being given from the beginning and passive movement after ten days. It is generally well to have a *skiagraph* taken after a limb has been put up, and, if the parts are not in satisfactory position *operation* may be necessary. In the upper third of the limb an incision along the anterior border of the deltoid, and in the lower two thirds along the external intermuscular septum is generally best. Damage to the musculo-spiral nerve must be carefully avoided. The parts may be fixed in position by plate, or wires may be used where the fracture is spiral.

Fractures of the Lower Extremity of the Humerus.

Transverse Supracondylar. This fracture is generally transverse from side to side, but oblique from behind forwards. When, as generally happens, the fracturing force, either direct, or indirect as from a fall on the hand, tends to produce hyper-extension of the elbow, the line of fracture is from above and behind downwards and forwards, and displacement is considerable. When, on the other hand, the fracturing force tends to produce flexion of the lower end of the humerus, the line is from above and in front, downwards and backwards, and displacement is less.

The lower fragment is drawn up by the biceps and triceps, the obliquity and fracturing force deciding whether it will go behind the upper fragment as it generally does, or in front.

Complications include injury to the vessels and nerves of the arm, particularly from the sharp edge of the upper fragment, which sometimes may even pierce the skin and render the fracture compound. Occasionally the joint may be involved by the line of fracture crossing the olecranon or coronoid fossa, or by a radiating fissure running into it.

Symptoms. In the more common type the forearm is pronated and is generally supported by the sound limb. When support is removed, flexion occurs at the point of fracture. Flexion at the elbow beyond a right

Fig. 17.—Transverse supracondylar.
Lower fragment is drawn up by biceps and I triceps. Obliquity of fracture determines whether fragment will go in front of or behind shaft.

angle is prevented by the bones of the forearm coming into contact with the lower end of the upper fragment. There is shortening of the upper arm, and crepitus can generally be elicited.

To *differentiate from a dislocation* the relationship of the olecranon to the condyles should be noted. In fracture the relationship is normal—when extended the three points form a straight line, when flexed they form an equilateral triangle with the apex directed downwards. In dislocation even when flexed, they form a triangle with the apex upwards. The deformity from

fracture is easily reduced, whereas that from dislocation is not, unless the coronoid is fractured.

Where the *obliquity is from before downwards and backwards* the displacement is generally slight, the lower end of the upper fragment becoming embedded in the triceps.

In children the lower fragment is often displaced, in addition, inwards and tilted so that the external condyle lies at an abnormally low level, producing marked cubitus varus :—adduction on extension of the elbow and abduction on flexion. This form is perhaps best treated in full flexion after reduction of deformity.

Treatment may be by Middeldorpf Triangle (q.v.) : or by extension, with the limb straight, or flexed at the elbow. The latter necessitates a series of extending pulls :—(1) upper arm extended and abducted by weight of ten pounds ; (2) forearm extended at right angles to upper arm by weight of five pounds ; and (3) a band going round upper arm just above flexure of elbow pulling backwards with weight of three pounds.

(1) Corrects shortening ; (2) brings lower fragment forwards ; (3) draws lower end of upper fragment backwards. Where the limb is put up extended, massage should begin at once and passive movement after eight days.

In cases of difficulty *operation* is generally the best treatment as accurate reposition is obtained, effused blood removed, and formation of excess callus minimised.

Separation of the lower epiphysis occurs generally between the ages of three and fourteen, from direct or indirect violence. Displacement is considerable.

The lower fragment may be displaced forwards from fall on the elbow, or backwards from fall on extended hand. The fracture is intra-articular.

There is abnormal mobility in all directions ; soft crepitus may be felt, and sometimes the upper end of the fragment can be palpated.

Treatment by Middeldorpf Triangle. If displacement cannot be rectified, operation should be performed by

uni- or bi-lateral incision, and parts fixed in position by screws. Extension of upper arm with forearm supinated, works well where there is no displacement. When the lower fragment is displaced backwards, extension of upper arm with forearm at right angles as described for transverse supracondyloid may be employed. Full flexion, without splint, is often employed, but requires careful attention as circulation is apt to be impeded.

In any case, massage should begin at once and passive movement after ten days.

T- and Y-shaped fractures, involving the joint, are generally caused by severe indirect violence, such as falls on the elbow from a height. There is frequently a wound at the elbow, and the fracture may be compound. It is not a common form of fracture and generally occurs in adults. The fragments, and particularly the inner, are more often displaced forwards than backwards. The signs are similar to those of transverse supracondylar fracture.

Treatment may be by operation through two lateral incisions. The two fragments may be united by a long screw introduced from side to side, and then the united mass attached to the lower end of the humerus by a plate; or a Y-shaped plate may be used with a limb for each fragment and one for lower end of humerus. Thereafter the limb may be put up in plaster or in extension, the latter permitting of massage from the outset.

Where operation is not performed the limb may be put up in extension with two transverse pulls at the elbow in opposite directions in order to try to approximate the fragments; or a Middeldorpf Triangle may be used.

In all cases there is apt to be limitation of movement after this fracture, particularly where the parts have not been fixed in position.

It is not bad practice to put the limb up in a Middeldorpf Triangle, beginning very slight passive movement after a week, and gradually increasing the movement

PLATE IX.

(1) Fracture of the Surgical Neck of Humerus.
(2) Colles' Fracture of Radius.

daily. At first only the forearm is released for movement, the upper arm being fixed in position. If this does not succeed then excision of the elbow may be performed, and, if properly carried out absolutely perfect movement can be obtained. In one such case the patient became a champion cricket bowler after excision of elbow of bowling arm.

Fracture of the External Condyle is comparatively common particularly in childhood. It may be due to direct or indirect violence, from falls on the hand or elbow. The fracture frequently involves a portion of the trochlea in addition to the capitellum and the joint is involved and swollen. The musculo-spiral nerve is apt to be damaged. Mobility of the fragment and crepitus may be elicited. Adduction at the elbow is abnormally free, and abduction causes pain by pressing the broken surfaces together.

Treatment. Operation with fixation of fragment by a screw is best. If not permitted extension by weight of about eight pounds with limb in position of full supination, kept up for about three weeks, with massage from first and passive movement after ten days, may suffice.

Fracture of the Internal Condyle is less common. It is generally caused by indirect violence, particularly falls on the flexed elbow, the force being transmitted through the olecranon. The ulnar nerve may be damaged and the joint is involved and swollen. Mobility of the fragment and crepitus may be elicited. Abduction at elbow is abnormally free and adduction causes pain.

Treatment by operation is best, the part being fixed in position by a screw. If not permitted, simple extension for three weeks, with massage and passive movement as above, may be employed.

The Epicondyles. The *internal* epicondyle is much more frequently affected, generally from direct but occasionally from indirect violence, such as falls on the hand. The fracture generally occurs in early life, and although extra-articular, effusion may occur into the

joint from injury to the capsule. In such cases it is possible for the small fragment to enter the joint through a rent in the capsule and interfere with movement. The ulnar nerve may be damaged.

The fragment can sometimes be palpated, and free abduction of the forearm at the elbow is permitted.

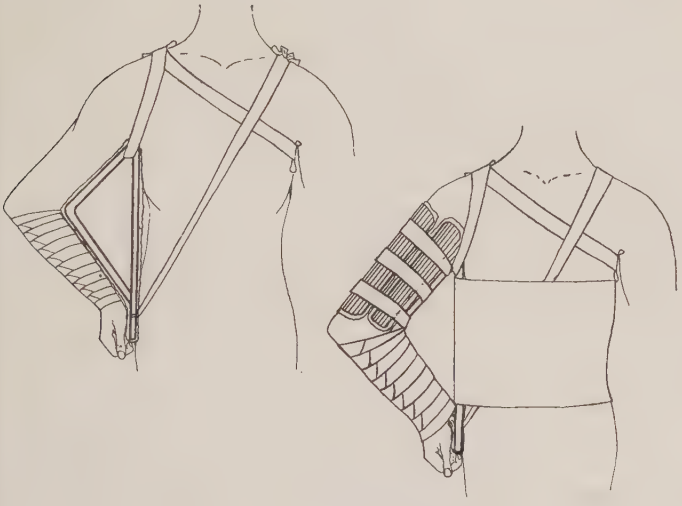
Treatment. Keep elbow at rest in position of flexion. It may also be operative, the fragment being fixed in position by a screw, or if lying free it is better removed.

Separation of the internal epiphysis may occur up to the age of eighteen from direct, indirect or muscular violence.

Fracture of the *external epicondyle* is rare and due generally to direct violence. The arm should be supported in a sling, and passive movement begun early. The *external epiphysis* may be separated between the ages of thirteen and seventeen by direct or indirect violence.

Middeldorpf Triangle. It will be noted that, in speaking of the treatment of fractures of the humerus, in practically every case where a splint is employed, the Middeldorpf Triangle has been recommended. This splint is often objected to as being awkward, and as necessitating the patient remaining in bed, as he cannot get on his clothes. The latter objection is inaccurate, as the clothes can be arranged to open at the side and tie over the inner limb of the triangle, so as to enable the patient to go about in the house. Its awkwardness is due to the position of the arm which is held in a position of abduction, which is necessary to bring the fragments in many cases into apposition. In addition to this advantage of position, the splint when properly fitted gives a marked passive extension of the upper arm, and, what is probably of greatest importance, the inner limb extends from the axilla down over the iliac crest and so remains fixed and does not yield to the constant heaving of respiration which is probably one cause of non-union of many fractures of the shaft of the humerus

when other splints are employed. The splint consists essentially of a triangle with a short extension at the lower end for the hand. Some make it with horns projecting upwards at the top, which, grasping the shoulder, prevent lateral movement, while others, with a view to preventing drooping when the patient is in bed, make the body piece broad so that it will rest on the bed and not sag.



(*a*) (*b*)

FIG. 18.—Middeldorpf Triangle.
(*a*) padded and applied. (*b*) completed.

In choosing a splint, care must be taken that the length of the portion on which the humerus rests is such that when padded, and the forearm flexed into position, the upper arm is in a condition of passive extension sufficient to correct deformity but not great enough to interfere unduly with circulation.

Having chosen the splint pass a single long tie of calico bandage through the holes in the hand piece; pad the

whole outer surface of the splint with lint, seeing that the angles at axilla and elbow are thoroughly protected, and fix the padding in position with a gauze bandage. The padded splint is now placed in position, and fixed there by two ties and a narrow binder. The tie already placed through holes in hand piece is carried up to opposite shoulder and tied there over a pad of lint. A second tie is passed through the axillary angle of the splint, tied and crossed on the injured shoulder, which is padded, and then the ends are carried down across the body and tied under the sound axilla. A narrow binder now encircles body and body-piece of splint and is pinned firmly in position.

The hand and forearm are generally bandaged with a calico bandage to prevent oedematous swelling, the fingers being left exposed. The upper arm is next laid in position after the deformity has been reduced, and the forearm gently but firmly flexed into position. As this is being done care should be taken to see that the upper arm is extended by the flexing movement, and that the arm is now quite straight. The hand and forearm are now bandaged to the splint by a second calico bandage laid over the former one.

Finally three strips of gooch, padded with lint, are laid along the upper arm, one mesial and one to either side, and these are fixed in position by three double ties with slip knots so that they can easily be undone for massage or readjustment. Speaking generally the patient should not be kept in bed with this splint—it acts more efficiently when the patient is upright. It will be noted that the passive extension corrects the tendency to upward displacement and consequent shortening of the lower fragment, while the abduction brings the lower fragment into line with the upper which in so many cases is abducted. The forearm is in a position of supination which is of advantage in treating separation of the lower epiphysis, and renders this splint an excellent method of treating fracture of the radius above the insertion of the pronator

teres, as well as all other fractures of the forearm where a position of flexion and supination is required. Where the Middeldorpf Triangle is employed for the *treatment of a fracture of the forearm*, the forearm is not bandaged, nor is it fixed to the splint by a bandage. A broad posterior wooden splint, padded with lint, is applied, which may be fixed in position by three ties or by screws, and winged nuts. The upper arm may be bandaged to the splint—it is not necessary to apply gooch.

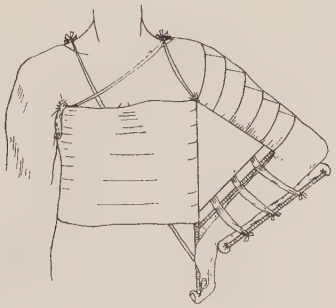


FIG. 19.
Middeldorpf Triangle applied for fracture of forearm where flexion and supination is desired.

As a temporary expedient while the proper splint is being made, a long strip of poroplastic may be cut and bent to the shape of a Middeldorpf Triangle.

Ambulatory extension for fractures of humerus.

A *Thomas' Splint* supplies a simple and rapid method of applying extension in fractures of the humerus, particularly useful when the patient has to be transported. Extension straps are applied from the shoulder to the finger tips, the straps either being left long or having calico bandages stitched to the extremities beyond the fingers. A splint of suitable size and length having been

chosen, it is prepared by fixing a series of double turns of flannel bandage across its breadth, so as to make cradles in which the arm rests. It is generally best to place these turns of flannel in position along one limb of the splint, and fix them to the other side by safety pins after the arm is in position. The splint is now

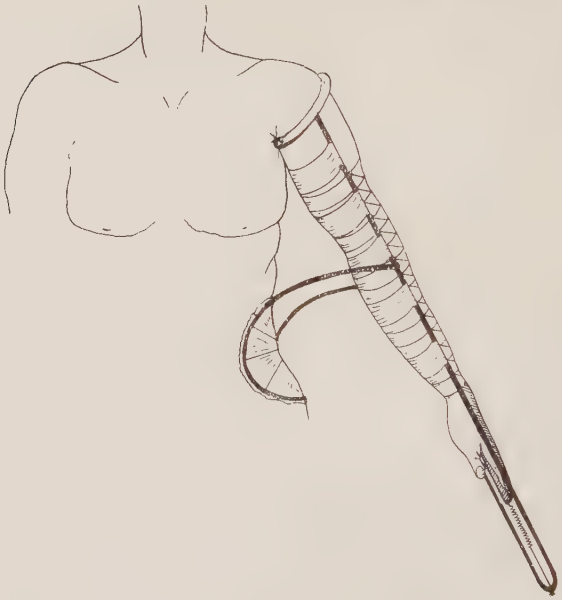


Fig. 20.
Thomas' splint with abduction bracket.

slipped over the arm, and the padded upper end is carefully adjusted to the shoulder and axilla. The ends of the extension straps are now given a turn round the sides of the splint and are finally brought down and tied together at the notch at the extremity, extension being applied by pulling them tightly before they are tied. If the extension be not sufficient it may be increased

by inserting a short piece of stick between the ends and screwing them up, the turn round the limb of the splint preventing any pressure on the arm. Another method of supplying extension is to insert a piece of elastic tubing between the ends beyond the fingers and the end of the splint.

Extension of the humerus with the arm at the side and the forearm flexed is easily supplied by a splint like a short Thomas', to the end of which the extension straps from upper arm are fixed, a spring or elastic

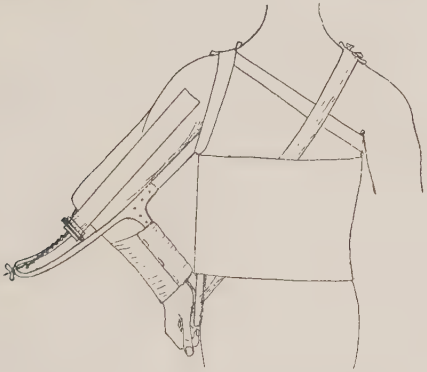


FIG. 21.
Middeldorpf Triangle with active extension.

intervening between the ends of the straps and the attachment to the splint. The forearm may then be supported by a sling.

Where possible the splint should lie at an angle to the body, thereby neutralising the abduction of the upper fragment. A degree of abduction can be easily maintained by fitting a bracket to the side, and if the forearm be flexed the splint becomes much less awkward.

A splint composed of stout telegraph wire or of aluminium may be constructed which will enable the patient to get about while keeping the limb in extension in the

abducted position. The general principle is that of the Middeldorpf triangle, with a nearly horizontal limb for the humerus. This horizontal limb extends well beyond the elbow and to its end are attached the extension plasters from the upper arm. Generally an elastic extension is supplied by means of rubber, or a spring let in between the ends of the plasters and the attachment to the splint.

After the wire frame has been made and fitted, it may be supplied with webs of flannel bandage like a Thomas' splint, or stiffened by substituting plaster or paraffin bandages for the flannel.

Extension can be applied on a Middeldorpf triangle by fixing a projecting loop of telegraph wire or aluminium to the lower end of the portion for the humerus. This can be rapidly accomplished with screw nails and staples and then the extension is attached to the end of the projecting loop.

Fractures of Bones of Forearm at Elbow Joint.

These include fracture of the olecranon and coronoid processes of the ulna, and of the head of the radius.

Olecranon. This fracture is generally due to direct violence, such as a blow or fall on the elbow; much less commonly to indirect violence, as in hyper-extension of the elbow from a fall on the hand, and to muscular action. It is occasionally compound.

The fracture occurs most frequently about the base of the process, the line being transverse or oblique, and involves the joint except where only a small scale of bone is detached from the upper end of the posterior surface. In this latter condition, as well as in those where the triceps aponeurosis is extensively torn, there may be considerable separation of the fragments: in other cases the separation is generally slight, and may be imperceptible. As in the case of the patella, but to a less extent, fragments of soft tissue may get

between the fragments when the separation is considerable, and interfere with union.

Symptoms. There is generally swelling from effusion into the bursa, or joint, or both. Flexion is painful; extension may or may not be possible, depending on the condition of the triceps aponeurosis and separation of the fragments. Sometimes the fracture can be palpated, and crepitus may be elicited by moving the fragment laterally. A skiagraph is useful.

Treatment. Where the *separation is slight*, the limb may be put up on a straight splint, or, if the separation be not increased thereby, on a wide-angled (greater than a right angle) or even on a rectangular splint. Massage and slight passive movement are commenced at the outset, care being taken that the fragment moves with the ulna and does not adhere to the humerus.

Where the *separation is considerable*, the fragment may be fixed in position by means of a metal *screw* or ivory or bone *peg* inserted through a small incision over the apex of the olecranon, and driven down into the shaft of the bone. Where there is reason to fear the interposition of soft tissues between the fragments, the parts should be exposed through a vertical incision over the olecranon, the soft tissues removed from between the fragments and stitched in position, and then the bones may be fixed as above or by means of stout catgut or wire introduced through holes bored for the purpose, through aponeurosis and bone—the aponeurosis should not be stripped.

Massage and passive movement should be commenced at once and the latter gradually increased. Active movements require care as it is possible for the patient to refracture the bone by vigorous muscular effort.

Where operation is refused, *extension* may be applied. The forearm is flexed at a right angle and placed midway between pronation and supination. A strip of plaster is run from beyond the finger tips along the palm of the hand, and the flexor aspect of forearm round the back

of the elbow, including the fragment of the olecranon, and so back along the extensor aspect and back of the hand to beyond the finger tips. A weight of six pounds is attached to this strap which pulls forwards. A counter-extension is applied by a strap of plaster which runs round the lower end of the humerus and to which a similar weight is attached pulling backwards. Lastly extension is applied to the upper arm by means of straps along the anterior and posterior surfaces, that on the anterior surface being split and separated to permit of passage

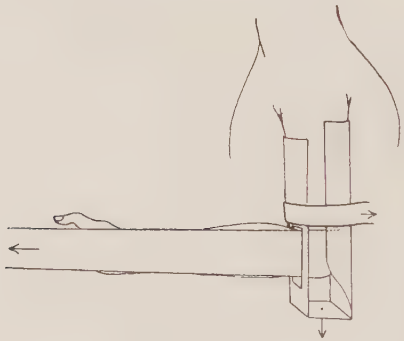


Fig. 22.
Treatment of fracture of olecranon by extension.

of the flexed forearm. A weight of six pounds is also applied here. The first strap tends to pull the fragment into position against the ulna, while the extension on the upper arm tends to pull down and relax the triceps. Passive movement should be commenced at once.

Union should be firm in six weeks.

Fracture of the **coronoid process** is rare, except as a complication of dislocation backwards. Diagnosis is best made by skiagraph, and treatment is by operation, when the fragment should be removed if it cannot be fixed in position.

Fracture of the **head of the radius** may be due to

direct violence, or indirect as from a fall on the palm of the hand. It may be comminuted.

Symptoms. Palpation of the head may reveal apparent enlargement, and crepitus may be elicited during pro and supination, but the condition should be confirmed by skiagraph. Movement soon after the accident may be fairly free, but may be impeded by loose fragments in the joint, and, later by callus formation. The musculo-spiral nerve may be damaged.

Treatment is operative with a view to fixing the fragments, or, if this be impossible, removing them. Where operation is not performed, passive movement should begin at once and in the intervals the forearm should be supported in a sling in a position midway between pro and supination.

Fracture of the **neck of the radius** may be due to direct, indirect, or muscular violence. It may be transverse or oblique, and while extra-articular, may be associated with a fissure running up into the joint. The upper end of the lower fragment tends to be displaced forwards, but there may be little or no displacement.

Symptoms. There is generally considerable swelling; pain, particularly on supination; and tenderness on pressure over the fracture. The head does not rotate on movements of pro and supination, but crepitus may be produced.

Treatment. Where there is no displacement, flex elbow at right angles, supinate forearm, and place in a posterior gutter splint (for details see fracture of radius above insertion of pronator radii teres). A Middeldorpf triangle may also be employed with advantage (p. 101).

Where the fragments are displaced, they should be fixed in position by operation, care being taken that both fragments are equally supinated. Passive movement should be commenced as soon as the wound is fairly healed.

The other fractures of the forearm requiring consideration are, Fracture of Both Bones; Fracture of Radius

above insertion of Pronator Teres; Fracture of Radius below insertion of Pronator Teres; Colles, and other fractures at lower end of Radius; Fractures of Shaft of Ulna and of Ulnar Styloid.

Fracture of both Bones of Forearm.

This may be due to direct or indirect violence, such as a fall on the hand, and rarely to muscular action. The fracture occurs generally in the middle or lower third, both bones breaking about the same level, although sometimes the radius breaks higher up when the cause is indirect violence. In children the fracture is not infrequently incomplete (greenstick). The line of fracture is often transverse, and the *displacement* slight, depend-

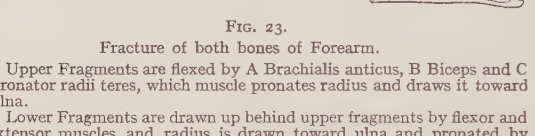


Fig. 23.

Fracture of both bones of Forearm.

Upper Fragments are flexed by A Brachialis anticus, B Biceps and C Pronator radii teres, which muscle pronates radius and draws it toward ulna.

Lower Fragments are drawn up behind upper fragments by flexor and extensor muscles, and radius is drawn toward ulna and pronated by D Pronator quadratus. E Supinator longus. F Supinator brevis.

ing rather on the fracturing force than on subsequent muscular action. The upper fragments tend to be flexed by biceps, brachialis anticus and by pronator radii teres, which muscle tends to pronate the radius and draw it toward the ulna. The lower fragments are drawn up, generally behind the upper fragments by the flexor and extensor muscles, the radius being drawn toward the ulna and pronated by the pronator quadratus. Deviation may, however, occur in almost any direction. As the muscles tend to draw the fragments together, *cross-union* readily occurs, with consequent loss of power of pro and supination unless this tendency be carefully corrected.

As the upper fragment of the radius is supinated by both the biceps and supinator brevis, and this action may only partially be neutralised by that of the pronator radii teres, there is danger of the radius uniting with its upper fragment in supination and its lower fragment in pronation. To obviate this possibility some argue that both bones of the forearm should not be put up midway between pro and supination as is usually taught, but in full supination.

Fractures of both bones may occasionally be compound, the sharp superficial posterior border of the ulna readily penetrating the skin.

Symptoms. Deformity, abnormal mobility and crepitus are generally marked, and diagnosis therefore easy.

Treatment. Deformity must be corrected, and, in so doing, a greenstick fracture may be converted into a complete fracture. The forearm is put up between anterior and posterior splints in a position of flexion and generally midway between pronation and supination. The splints may be of gooch, with the wood side next the skin, but are better made of wood, sufficiently thick to prevent yielding when the ties are applied. The length is from the knuckles to beyond the elbow, and the breadth such that the ties cannot touch the limb when put up and therefore flattened out by pressure. Pieces should be cut out to prevent pressure on the ball of the thumb and the external and internal condyles of the humerus, or, if this be not done, additional padding should be placed in the hollow of the hand, and cotton wool nests placed over the condyles. The splints should be padded with lint, and fixed in position by means of three double ties with slip knots. Care must be taken to see that the splints are parallel, as, unless they are, they tend to press the bones toward one another. This danger is minimised by allowing the splints to project beyond the elbow as directed. Exact parallelism may be secured and the amount of pressure regulated by means of long bolts passed through holes in both splints

and fixed by winged nuts. In cases where there is great tendency for the bones to come together, narrow *interosseous pads* of lint may be used to force them apart, but they must be used with care, and the circulation watched carefully during their use. Finally the forearm is supported in a sling.

The *deformity is corrected* by flexing the elbow, which relaxes the flexor muscles; by placing the limb midway between pro and supination whereby the pronators are relaxed; by using broad splints placed parallel, whereby the tendency of the fragments to come together is corrected—supplemented, where necessary, by interosseous pads. In all cases the circulation should be carefully

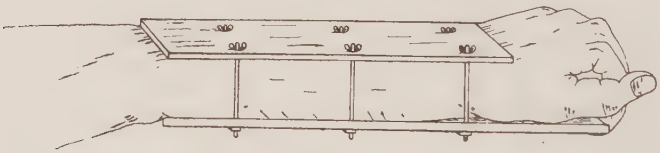


Fig. 24.

Treatment of fractures of forearm by splints fixed by bolts and screws (Padding omitted for clearness).

watched and the possibility of Volkmann's Ischaemic Paralysis supervening remembered.

Passive movements of the fingers should be commenced at once, and massage after three or four days, the limb resting on one splint while the other surface is massaged. Passive movement of the wrist should also be performed. Passive movement of the elbow should be commenced after a fortnight, and the splints may be discarded after three to four weeks, the sling being used for about a week longer.

Some advocate the putting up of fractures of both bones in full supination instead of midway between pro and supination because, for reasons already stated, in full supination the danger of union of the fragments of radius in different degrees of supination is minimised,

and further, the danger of cross union is likewise minimised as the space between the bones is greatest in this position. As a position of flexion and full supination with the forearm across the chest is uncomfortable, the position is best attained by applying a Middeldorpf Triangle (q. v.) with a broad splint on the posterior aspect of forearm secured by ties or by bolts and winged nuts.

Where there is difficulty in correcting the displacement the bones may be wired or plated, care being taken that the arm is exactly in the same position while each bone is being fixed and that the fragments are in a similar degree of supination while they are being united.

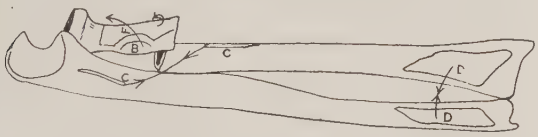


FIG. 25.

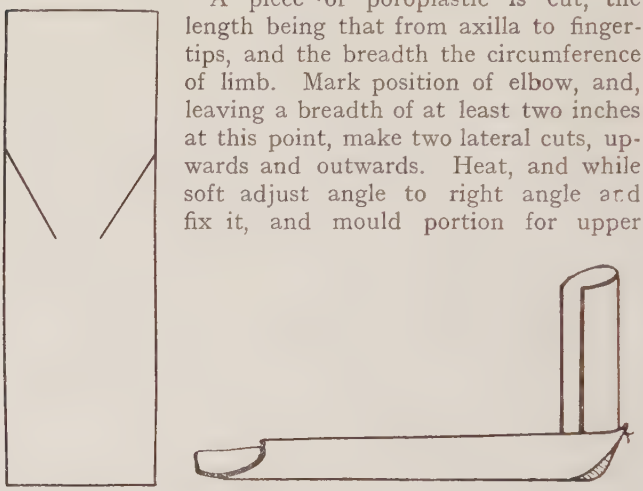
Fracture of Radius above insertion of Pronator. Upper short fragment is fully supinated by F, Supinator brevis assisted by B, Biceps, which also produces flexion. Lower fragment is pronated and drawn toward Ulna by C, Pronator teres, and D, Pronator quadratus.

FRACTURES OF SHAFT OF THE RADIUS.

Fracture **above the insertion of the Pronator** Radii Teres is more often due to direct violence. The upper short fragment is fully supinated by the supinator brevis assisted by the biceps, which also produces flexion. The lower fragment tends to be pronated and drawn toward ulna by the pronators.

Treatment. As the short upper fragment is difficult to control, the limb must be placed in the position which it has assumed—namely in flexion and full supination. This position, with the forearm slung across the chest, is not very comfortable, whereas the position is attained with comfort by placing the limb on a Middeldorpf triangle (p. 101). In this case the upper arm is bandaged to the splint and the three short pieces of gooch are dispensed with.

If the cross-chest position be preferred, a right-angled posterior splint may be used, or a splint may be constructed from poroplastic.



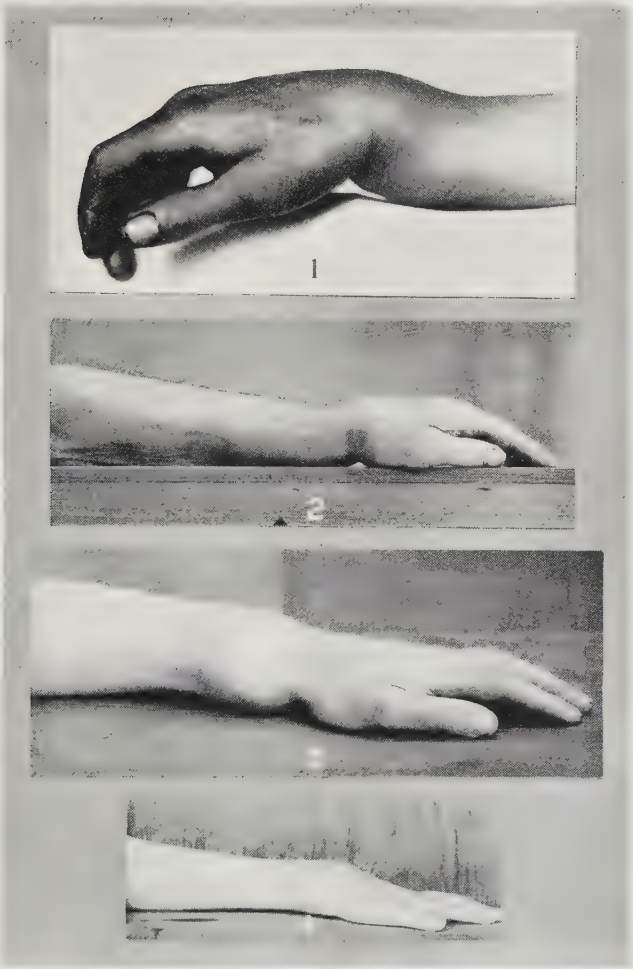
(1) (2)

FIG. 26.

Poroplastic splint for Fracture of Radius above Pronator.
(1) Poroplastic cut, ready for heating and moulding. (2) Finished splint.

A piece of poroplastic is cut, the length being that from axilla to finger-tips, and the breadth the circumference of limb. Mark position of elbow, and, leaving a breadth of at least two inches at this point, make two lateral cuts, upwards and outwards. Heat, and while soft adjust angle to right angle and fix it, and mould portion for upper arm in complete circle, that for upper end of forearm also in circle, while that for lower end of forearm and hand is shovel shaped. Pad with cotton wool or lint, and apply. A short anterior splint of gooch may also be applied extending over palm of hand to ensure that the position of complete supination is maintained, but is unnecessary if poroplastic is of correct shape. The splint may be fixed with ties or bandages, and the forearm supported by a sling. Massage should be commenced early, as likewise passive movement of the fingers and wrist. The elbow joint can be moved without removing the splint, if the fixation at elbow be undone. The splint may be removed at the end of three weeks and the sling a week later.

PLATE X.



(1) and (2) Colles' Fracture of Radius.
(3) Sarcoma of lower end of Radius.
(4) Tubercle of wrist.

Fracture **below the insertion of the Pronator** is also more frequently due to direct violence. The upper fragment is flexed by the biceps, but the supinating action of biceps and supinator brevis is counteracted by the pronator, so that the upper fragment lies in a position midway between pro and supination. The lower fragment is pronated by the pronator quadratus. Both fragments are drawn toward the ulna by the pronators.

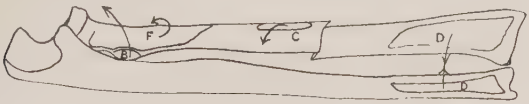


FIG. 27.

Fracture of Radius below insertion of Pronator.

Upper Fragment is flexed by B Biceps, but supinating action of B and of F Supinator brevis is counteracted by C Pronator teres, so that upper fragment lies midway between pro and supination.

Lower fragment is pronated by D pronator quadratus. Both fragments drawn toward Ulna by C and D.

The *treatment* is the same as for both bones of the forearm, the arm resting in a position of flexion, midway between pro and supination, whereby the displacements are neutralised. Some writers urge that this fracture should be treated, like fracture above the insertion of the pronator, in full supination, in which case a Middeldorpf Triangle might be used (p. 101).

ULNA.

Fracture of the **shaft of the Ulna** alone is generally due to direct violence. The fracture more often occurs below the middle of the bone, and the displacement is due largely to the fracturing force, the ends of the fragments as a rule being directed toward the interosseous space. Irregularity of contour may be detected by palpation, and abnormal mobility and crepitus may be elicited.

Treatment as for both bones of forearm, or in full supination as for fractured radius above insertion of pronator, may be employed.

Fracture of the **ulnar styloid** occurs most frequently as a complication of Colles' fracture. The fracture may be transverse but is frequently oblique, causing a very sharp edge, which may readily become compound. It may also be caused by direct violence, as in a case of the writer's from a blow from a polo stick. The moveable fragment was easily palpated subcutaneously, but was confirmed by X-ray examination. Treatment by keeping forearm in sling with hand deflected to ulnar side was entirely successful.

In cases of fracture of the bones of the forearm where satisfactory position is not otherwise obtained, **extension**,

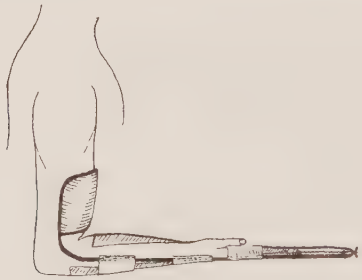


FIG. 28.
Treatment of fracture of bones of forearm by extension in supination.

with the forearm supinated, may be tried, and if this is not satisfactory operation may be resorted to.

It is not necessary to keep the patient in bed in order to apply the extension, a splint on the Thomas principle acting well. The splint should extend well beyond the finger tips, and at the elbow it is bent at right angles and extends four or five inches along the upper arm. In place of the padded ring at the upper end a plate of metal moulded to fit the front of the upper arm is used. When the extension is applied in the usual manner this plate presses against the upper arm, thereby providing counter-extension. If necessary the splint may be

retained in position by a few turns of bandage, but generally the extension suffices, and the forearm is supported in a sling. Supination is maintained by means of a flannel bandage sling stretched tightly from side to side across the palm of the hand, or by strips of adhesive plaster, attached to the frame. If the splint be provided with a moveable joint at the elbow, passive movement can be easily applied without removing the splint.

Colles' Fracture of the Radius. This is one of the most common fractures met with in practice. It is practically always caused by indirect violence, particularly

FIG. 29.
Colles' Fracture.
Lower fragment, carrying with it the hand, is displaced upwards and backwards and rotated so that h nd is turned to radial side. Lower end of upper fragment projects anteriorly and lacerates pronator quadratus, which muscle tends to draw it toward the ulna.

falls upon the hand, with the elbow extended. The fracture occurs more often in elderly persons, particularly females. The fracture occurs about three-quarters of an inch above the articular surface, and is generally transverse from side to side, but oblique from above and behind, downwards and forwards. The displacement is probably entirely due to the fracturing force, and is generally only partial. The lower fragment, carrying with it the hand, is displaced upwards and backwards, and rotated on its antero-posterior axis, so that the hand is turned toward the radial side. Particularly in old persons this rotation is frequently due to compression-

crush of cancellous tissue. Impaction of the fragments is common, the upper fragment being driven into the lower, and tending to split it, the split sometimes extending into the joint. In addition to the fracture itself the internal lateral ligament of the wrist joint is frequently ruptured, and sometimes the triangular fibro-cartilage of the ulna at the wrist joint is torn. Where impaction is not complete the lower end of the upper fragment tends to project forwards and lacerate the pronator quadratus.

The radial styloid, moving with the lower fragment, is displaced upwards and backwards and thus comes to lie at a higher level and in a plane posterior to that of the ulnar styloid.

Many **varieties of fracture** occur at this point, and writers differ as to whether they should all be classed as Colles' fractures.

The fracture, for example, may be transverse both from side to side, and from before backwards; a vertical split may run down from the fracture to the joint, without impaction having occurred; the lower fragment may be comminuted; the styloid of the ulna is very frequently broken off; the carpus may be fractured or dislocated. The inferior radio-ulnar ligaments may be ruptured as well as the triangular fibro-cartilage, and the bones thus become separated. The tendon sheaths are frequently lacerated, blood being effused into them, but the nerves and vessels are rarely damaged.

Barton's fracture is a vertical fracture in the lateral plane which, commencing at the articular surface of the radius, runs upwards and backwards to emerge on the posterior surface, the anterior surface remaining intact.

A *Chauffeur's fracture*, due to the blow on the hand from the backfiring of an engine when being started with a starting handle, may be a typical Colles', or may consist of separation of the styloid process of the radius, or may be an oblique fracture extending from the articular

surface upwards and toward the radial side, separating a considerable wedge-shaped portion of bone.

Smith's fracture is the reverse of a Colles', due to a fall on the back of the flexed hand, the lower fragment being displaced forwards or maintaining its position.

Separation of the lower radial epiphysis occurs most frequently in males about fourteen years of age, and may be due to direct or indirect violence. Frequently the line of separation does not adhere to that of the epiphysis but includes a portion of diaphysis posteriorly. The fragment may not be displaced, or may be displaced as in Colles'. Arrest of growth may result with subsequent apparent enlargement of the lower end of ulna and radial deflection of hand.

Symptoms. The deformity produced by a typical Colles' fracture is characteristic, and is often described as 'Silver fork' when looked at sideways. The prongs represent the fingers, while the dip on the back of the fork represents the dip which occurs at the junction of the lower and upper fragments. Corresponding to the dip posteriorly, there is a prominence in front from projection of the lower end of upper fragment. The hand is markedly deflected to the radial side, and the lower end of ulna is unduly prominent. The fingers are generally slightly flexed owing to stretching of the tendons, and movements of the wrist are interfered with. Abnormal mobility and crepitus are of course absent where there is impaction.

The *condition requires to be distinguished from sprain;* backward dislocation of the wrist, separation of lower radial epiphysis, tubercle of the wrist joint, and sarcoma of the lower end of radius.

Simple sprains are not very common, and the absence of fracture should be verified by skiagraph. In *dislocation*, which is not common, the styloid processes retain their normal relationship—the radial being below and anterior to the tip of the ulnar—while the rounded edge of the carpal bones can be palpated posteriorly, contrast-

ing with the sharp edge of the lower fragment in fracture, and lying at a lower level. Further, the hand tends to be deflected toward ulnar side. The dislocation is extremely easily reduced by gentle traction.

In *separation of the lower epiphysis* the deformity is generally less marked; is more noticeable on the palmar surface, and deflection of the hand to the radial side is generally absent. Crepitus is generally soft. The swelling is as a rule fusiform and confined to the wrist joint, thus being below the area of Colles' fracture, while the styloids retain their normal relationship to one another.

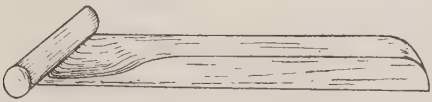
In *sarcoma* the swelling is generally fusiform; may extend considerably above the area of fracture or dislocation, and the radial styloid maintains its position or may be displaced still further down. If the hand be deflected, it is generally toward the ulnar side. Sarcoma is not infrequently associated with fracture.

Treatment. As has already been pointed out this fracture is particularly suited to treatment by Championniere's massage and passive movement method (p. 11).

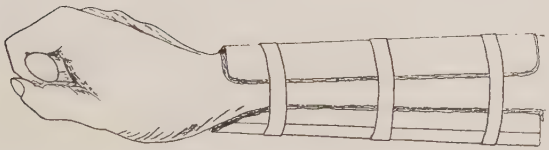
The first point in treating a Colles' fracture by ordinary methods (after removal of rings on fingers which if left until swelling occurs may cause gangrene) is to *reduce the deformity*, and, if necessary, impaction must be broken down to effect this, very considerable force being frequently required. Grasping the patient's forearm with one hand, the surgeon takes the affected hand in his other, as in shaking hands, and applies traction, deflexion to the ulnar side, and flexion of the wrist; while with his thumbs, he endeavours to push the lower fragment down and forwards into its position.

Carr's splint is generally employed, but a substitute may be made by nailing a piece of broom handle obliquely across one end of a piece of wood the breadth of the wrist, whose length is from the knuckles almost to the elbow. The obliquity of the broom handle is such that when grasped by the hand it overcorrects the deflection to radial side. A short piece of wood should also be nailed

along radial border of splint ending at lower end of upper fragment. The splint is padded with lint in two or three folds, which need not be bandaged on. The hand is now made to grasp the roller, and the forearm is laid along the splint. A short dorsal splint, also padded with lint, is next applied, extending from the *wrist* up to near the elbow, and is fixed in position by ties or bandage. Three double ties shold be used, or if a bandage be employed it should run from the wrist upwards. The fingers and hand must not be bandaged in.



Carr's Splint.



Carr's splint padded and applied.
Fig. 30.

The radial deflexion is corrected by the deflexion of the hand roller to ulnar side; the hollow between the hand-roller and thick support for the forearm facilitates the reduction of the backward displacement of the lower fragment, which is completed by the pressure of the short back splint.

The limb, fixed in splint, is supported by a sling. *Massage* of the hand and fingers, and *passive movements* should be commenced at once and be carried out frequently. After about five days the posterior splint should be regularly removed and passive movement of the wrist carried out in addition. Passive pro and supination should be

begun at the end of a week, and active movements of the wrist after two weeks. The splint may be removed at the end of three weeks, and the sling a week later.

Some writers treat Colles' fracture, particularly where there is no deformity, with a *sling alone*, the sling extending only to the wrist, and supporting the ulnar border, so that the hand, which is not supported, droops to the ulnar side, whereby the radial deflexion is corrected.

It is of the greatest importance to attend from the outset to the *movements* of fingers and wrist in a Colles' fracture, as, unless this be done, they are very apt to become fixed and useless.

Carpus.

Fractures of the bones of the carpus are not very common, but may easily be overlooked. They may be due to direct or indirect violence. The *scaphoid* is most frequently affected, particularly in adult males, and generally from falls on the outstretched hand, the fracture being generally transverse and proximal to its middle, giving rise to pain and swelling over the dorsal surface of the wrist on the radial side with sharp pain on pressure in the "Tabatière." Diagnosis should be confirmed by skiagraph of both hands (for comparison) in pronation. *Treatment* consists in fixing hand in flexion to radial side; massage from the beginning, and passive movement after three weeks. Excision may be necessary. An "*intercarpal luxation fracture*" consists of fracture of the scaphoid combined with dislocation forward of the semilunar. The *semilunar and os magnum* are also occasionally fractured alone, and when the os magnum is fractured its head may be displaced and project on the dorsal surface of the wrist. The other bones are rarely fractured singly.

Where several bones are fractured, efforts should be made to reduce effusion by elastic pressure and later by massage, passive movements of the fingers being begun at once, and those of the wrist after ten days.

Metacarpus.

Fractures of the metacarpal bones are much more common and may be due to direct or indirect violence. The fracture may be transverse, oblique, or spiral, and occurs generally about the middle of the bone. Displacement when present is largely due to the fracturing force, the proximal end of the distal fragment being either displaced toward the palm or toward the dorsum—if the latter it may be compound. Longitudinal fractures sometimes occur and are apt to be diagnosed as sprains.

Symptoms. Swelling and ecchymosis are generally distinct on the dorsal surface. There is tenderness on pressure over the seat of fracture, and when applied in the long axis of the affected finger. The head of the bone is often somewhat depressed, and this is most marked when the hand is shut and the knuckles are examined. Abnormal mobility and crepitus can generally be elicited.

Treatment, where there is no deformity, or the distal fragment projects into the palm, may be by means of a roller bandage which is grasped by the closed fist. Firm traction is applied to the finger corresponding to the broken bone, and then it is carefully bent into position along with the other fingers. Small pledgelets of gauze are placed between the fingers and then the hand is bandaged in position, and may be supported in a sling.

Where there is marked deformity or shortening, extension is necessary. Apply a strip of adhesive plaster along the front and back of the finger, extending from the centre of the palm in front and a corresponding point behind, to beyond the finger tip. Fix it in position by a turn of adhesive strapping round the hand, and several turns round the finger. Next attach a piece of elastic or rubber tubing to the end of the extension plasters, and to the free end of the elastic attach a couple of tapes. A wooden splint, the breadth of the wrist,

is next padded with lint down to the level of the knuckles and applied, preferably to the dorsal aspect of the forearm and hand, extending from the middle of the forearm to six inches beyond the finger tips, and is fixed in position with adhesive strapping. The elastic is now stretched by pulling on the tapes, which are tied round a screw nail inserted in the end of the splint. As the padding of the splint ends at the heads of the metacarpal bones, both extension of the fractured bone and hyper-extension of the metacarpo-phalangeal joints is produced; the flexor tendons are consequently stretched and tend to force the head of the fractured bone backwards and its fractured extremity forwards. Passive movement is begun about the fourth day and active movement after a week.

Bennet's fracture is caused by falls or blows on the point of the thumb and consists of an oblique fracture of the base of the first metacarpal, which detaches part of the articular surface and the piece of bone supporting it which projects into the palm. The larger fragment is displaced backwards. The condition is apt to be diagnosed as a sprain, and an X-ray should therefore be taken. The deformity due to backward displacement of the larger fragment is reducible by traction. *Separation of the epiphysis of the first metacarpal*, situated at the proximal end, may occur in young persons from similar injuries.

Both conditions may be *treated* by applying a wooden splint to the forearm and hand, which has a lateral projection for the thumb. The splint is well padded with lint over the forearm and hand portions, but less over that for the thumb. The thumb is fully extended by traction and fixed to the splint in a position of abduction by adhesive strapping, and the splint is fixed to the forearm by further turns of adhesive strapping. Massage is begun at once, and passive movement after a week.

Phalanges.

Fractures of the phalanges may be due to direct or indirect violence, and are frequently compound. They may take any direction, vertical fractures being more common in the phalanges than elsewhere. The presence of these should be suspected where the bone is abnormally broad.

Treatment may generally be effected by means of a short anterior wooden splint to which the affected finger is fixed by adhesive strapping. Sometimes, however, extension may be necessary. Passive movement should be commenced early, and particularly where a joint is involved.

Busch's fracture consists of the tearing of a fragment of bone from the front of a terminal phalanx by the action of the flexor profundus tendon, following upon which the patient is unable to flex the terminal phalanx. *Treatment* is rather unsatisfactory, and is generally confined to massage.

Pelvis and Lower Extremity.

Pelvis.

Fractures of the Pelvis occur most frequently in early adult life, particularly in males, from severe violence. The violence generally takes the form of crushing, but even when a fracture of the pelvis arises from a fall on the ischial tuberosities the fracture caused is usually the same as that which arises from crushing. The *common form of fracture* of the pelvis consists of (*a*) a fracture of the rami of pubes and ischium, the former being fractured near the ilio-pectineal eminence; the latter further back, toward the ischial tuberosity, and (*b*) a tearing of the sacro-iliac ligaments, or fracture of the sacrum or ilium near the insertion of these ligaments. The fracture is described as occurring from direct or indirect violence—*from direct violence* when the crush-

ing force is applied antero-posteriorly, the rami giving way as described near the anterior point of application of the force, after which the blades of the pelvis tend to be forced apart, whereby the anterior sacro-iliac ligaments are ruptured or the ilium or sacrum fractured vertically by avulsion; *from indirect violence* when the force is applied laterally, and the rami having fractured as before, the blades tend to be forced together, and the posterior ligaments are torn, or more commonly, the ilium (rarely the sacrum) is fractured by avulsion. When the compressing force is applied obliquely the rami may

Fig. 31.
Common fracture of Pelvis through rami of pubes and ischium.

be fractured on one side, and the ilium on the opposite side of the body. The fracture is sometimes bilateral anteriorly, and may even be so posteriorly.

Separation at the symphysis is not common, but may occur in child-birth, or from a blow, as from the pommel of a saddle. Separation at the pubic and iliac synchrondroses, rarely produced by great violence, is called a '*dislocation of the innominate.*'

Any part of the pelvis may be broken by direct localised violence. The crest of the ilium may be separated in whole or part; a portion of the ala may be detached by an oblique fracture; the anterior superior and inferior spines may be broken off, sometimes from muscular

action, and the latter may be separated as an epiphysis. The ischial tuberosity may be detached, and portions of the acetabular margin, generally from the posterior aspect, and accompanied by dislocation of the hip, may be similarily affected. Violence acting through the head of the femur has rarely produced radiating fracture of the acetabulum, and still more rarely has the head of the femur been driven through the acetabulum into the pelvis.

Fractures of the *sacrum alone* are uncommon. The line of fracture is generally transverse, and the lower end of the lower fragment is displaced inwards toward the rectum which is pressed on and may be torn, while the sacral nerves may be damaged, causing paresis of the bladder, rectum, and lower limbs.

Fracture of the *coccyx* is likewise rare, and the fragment is also displaced inwards toward the rectum, causing severe pain when walking or sitting, while *coccydynia* may develop and necessitate removal of the fragment by operation.

Symptoms. While in many cases there is a very considerable degree of shock, a patient may be able to walk after sustaining a fracture of the pelvis. Often the limb on the affected side is everted, appears longer than its neighbour, and patient is unable to raise it without pain and difficulty. Attempts should not be made to elicit crepitus: they are often unsuccessful, and tend to produce complications if these do not already exist. The soft tissues are generally swollen and discoloured over the points of fracture. The fractures of pubes and ischium are generally easily palpated in groin and perineum, while those posteriorly may be made out by external palpation or rectal examination. A skiagraph should be taken to confirm diagnosis.

Of more importance than the fracture of the pelvis, as a rule, are the **complications** which may occur, and which should be suspected and looked for. Of these, *rupture of the urethra* is the most common and important,

as, if neglected, extravasation of urine, with distension and sloughing of the parts, and death may readily occur. Inability to pass urine, or passing of blood, or dripping of blood from the urethra, generally indicate urethral damage. In such cases a silver catheter should be passed into the bladder and fixed in position, or, if this be impossible, supra-pubic puncture with passage of a soft catheter through the cannula which is then withdrawn, leaving the catheter in situ, may keep matters right until operation can be performed. If *extravasation* be present, perineal section should be performed at once, and a catheter introduced into the bladder, while multiple incisions may be required to permit of the escape of extravasated urine.

Injury to the rectum is perhaps next most common, the fracture being thereby rendered compound and probably septic. *Rupture of the bladder* occurs occasionally, intra-peritoneally about the fundus, or extra-peritoneally about the neck; and other viscera, including bowel, are sometimes involved. Nerve roots and iliac vessels are sometimes stretched or torn.

Treatment of uncomplicated fracture consists in applying a narrow binder round the pelvis, extending below to the tips of the great trochanters; fixing the knees and ankles together by a few turns of bandage after a little padding of cotton wool has been placed between them, and placing the patient flat on his back, with a sand pillow on either side. This should be kept up for six to eight weeks. The binder is kept narrow to facilitate the use of the bedpan without moving the patient, and, with this object in view, a four piece mattress should be used.

Fracture of the ischial tuberosity may require fixation by operation: separations of the epiphysis of the inferior iliac spine or of the crest are generally treated by rest in bed with flexion of the thigh for two weeks, after which the limb is gradually straightened. Massage should also be given. These parts may also require fixation by operation on occasion.

Femur.

Fractures of the Upper Extremity. These include intra- and extra-capsular fractures of the neck: separations of the epiphysis of the head: fractures and separations of epiphyses of great and lesser trochanters.

Intra-capsular fracture of the neck occurs most frequently at the junction of head and neck; most often in old persons, and particularly females, as the result of slight indirect violence. Impaction is less

Fig. 32.—Fractures of the femur.

A, Neck: Intracapsular.
B, Neck: "Extracapsular."
C, Shaft: Upper third.
D, Shaft: Middle third.
E, Shaft: Lower third.
F, Separation of lower epiphysis.

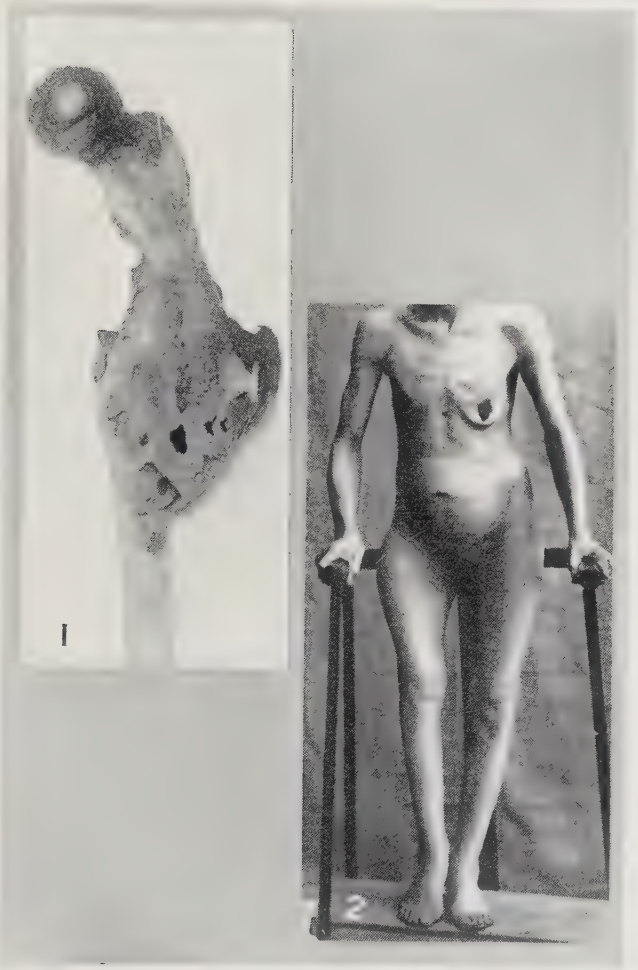
common than in the extra-capsular form, and, when it does occur, the narrow neck is driven into the broad head, the impaction generally being most marked at the postero-inferior aspect. As the vascular supply is frequently defective owing to injury to the periosteal vessels, osseous union is often imperfect or may not occur, while sometimes the neck may undergo absorption. It should be remembered that in old persons the neck

is rendered more liable to fracture because the angle between neck and shaft is often diminished (sometimes to a right angle); the compact outer layer of bone of the neck is thinned, while the cancellous tissue has undergone fatty degeneration, and the calcar femorale of Merkel which runs in the interior of the neck from the small trochanter to the under part of the head, is absorbed.

"Extra-Capsular" Fracture of the neck. An entirely extra-capsular fracture of the neck is anatomically impossible, as the capsule follows the line of junction of neck and shaft in front, although posteriorly it is inserted into the neck about half an inch above the posterior intertrochanteric line. Thus a fracture of the neck may be extra-capsular behind, but cannot be so in front, while frequently, owing to the thickness of the **Y**-shaped ligament, the fracture runs through the insertion and is neither extra- nor intra-capsular in front.

This fracture occurs about the base of the neck, sometimes however even running outside the insertion of the capsule in front ('inter-trochanteric') and is met with generally in males in the prime of life, as the result of severe direct violence. Impaction is common, the neck being driven into the upper end of the shaft, which may be fissured thereby and the impaction sometimes broken down. In this form an abundant blood supply is conveyed to the upper fragment by the vessels running in the thick periosteum of the neck and good osseous union is the rule. Sometimes **V**- or **Y**-shaped fractures, with the apex toward the small trochanter, are produced; or a quadrilateral portion of bone including the great trochanter may be separated, or a similar portion including both trochanters may be detached. The small trochanter may likewise be separated along with a piece of bone from the postero-internal aspect.

Separation of the Epiphysis of the head is a rare injury; occurring most frequently about the age of eighteen. The separation may be incomplete, and the patient may be able to get about until either the separation is com-



(1) Malunited fracture of femur in upper third with great callus formation.
(2) Old ununited fracture of femur in upper third.

pleted by the weight of the body, or the parts yield and a traumatic coxa vara is produced.

Symptoms. In both forms of fracture of the neck there is shortening from a half to three inches, depending upon impaction and amount of destruction; and the limb is abducted, rotated outwards, and sometimes flexed. Movement is generally very painful and almost impossible, but a patient with impaction has been known to walk a short distance.

Shortening is due to the action of the glutei, hamstrings, adductors, and rectus; while the eversion is due

FIG. 33.—"Extracapsular" fracture of neck of femur. Shortening due to action of adductor, rectus, etc. Eversion due to ilio-psoas, adductors, weight of foot, etc.

to the action of the ilio-psoas, adductors, etc.; the weight of the limb and foot; and the fact that the osseous tissue of the neck is more fragile behind than in front, comminution, compression, and impaction, therefore, being more extensive in that region. Shortening is estimated by measuring both limbs, placed in the same position, from the anterior superior spine to the adductor tubercle.

Displacement upwards of the great trochanter is estimated by *Nelaton's line*—from the anterior superior spine to the tuber ischii. The great trochanter should normally just touch this line, while in fracture or dislocation it is above it. The displacement may also be

estimated by use of *Bryant's triangle*: with patient lying flat on the back, drop a perpendicular from the anterior superior spine; draw a second line from the tip of the great trochanter to meet this line at right angles. The difference in length of this second line on the normal and affected sides gives the amount of displacement.

Allis's test consists in pressing with the fingers midway between the iliac crest and the great trochanter on both sides simultaneously, and estimating the amount of tension of the tissues. It is less on the affected side.

These tests, together with X-ray examination generally render diagnosis definite, without the necessity of eliciting crepitus, which, if energetically sought for, may cause breaking down of useful impaction or give rise to further damage.

Prognosis depends greatly on the age and health of the patient. Where the patient is comparatively young and strong, recovery with a more or less useful limb is generally to be expected, but where the patient is old and feeble, life may be gravely endangered, and, even if preserved, bony union may not occur. Hypostatic congestion of the lungs is ever to be feared when old persons are required to lie flat on the back, and pulmonary embolism, bed sores, and other complications may readily occur in spite of care.

Treatment *of fractures of the neck generally.* If the fracture be impacted, and the position is good, without undue shortening, maintain the impaction. When the patient is old it is often wise to maintain the impaction even when the position is not particularly good. When the fracture is impacted, and the position bad, the impaction should be broken down, under anaesthetic if necessary, and the limb put up in extension with abduction. The patient may be propped up in bed after a few days.

Where there is no impaction the limb may be put up in a splint or preferably in extension with abduction.

Of Intracapsular Type. Where the patient is old and feeble, the limb should be placed in a *Thomas' splint*, with extension, the patient allowed to sit from the first, and got out of bed as soon as possible. If the padded ring at the upper end of the splint be removed and the *wooden ring of an Erskine pattern temporary limb* (q.v.) substituted (by which patient rests his weight on the tuber ischii), he may walk on the splint if given crutches and a patten on the boot of the sound limb.

FIG. 34.
Thomas' splint with extension applied and increased by Spanish windlass. No foot piece.

The splint should be of such length that the lower end projects well beyond the foot when the ring at upper end is pressed against tuber. It is prepared by applying a series of double turns of flannel bandage along one of the bars of the splint, the bandages ultimately being fixed by safety pins or by stitching to the other bar, so as to form a series of cradles for the thigh and leg. Extension straps are applied to the limb as usual, extending from the level of the groin to the malleoli, where

they are replaced by calico bandages. It is often an advantage to put on a thick sock and stout leather slipper or light boot on the foot of affected limb. The splint is now slipped into position, the foot piece, if present, is adjusted to the foot to prevent drooping of the toes, and then the ends of the extension are given a turn round the sides of the splint, and tied at the bottom of the splint, after being pulled down tight. Extra extension may be applied by inserting a piece of stout wood between the extension straps of bandage at the lower end, and twisting up ('Spanish windlass'), the turns round the sides of splint preventing pressure on the malleoli or foot. So long as the patient is in bed, the splint should be placed in abduction, and the foot raised on a pillow or bracket. Where there is no foot bracket care must be taken to support the foot at right angles to the limb so as to prevent drop-foot.

Treatment by means of *extension strapping* alone may be adopted, but a foot bracket or inverting pull is generally necessary to correct eversion. The patient should be propped up in bed after the first couple of days. It is generally necessary to get the patient up, irrespective of satisfactory healing, after a week or so, the limb being encased in plaster, a patten on the sound foot and crutches being provided.

If the patient with intra-capsular fracture is able to stand it, an *operation* may be performed.

(*a*) an attempt may be made to fix the head in position by means of a steel pin or screw driven in through the base of the great trochanter and up along the interior of the neck. This is a comparatively slight operation, but satisfactory results are sometimes difficult to obtain. (*b*) the head may be excised with good results.

(*c*) Where the patient is younger and in good condition an incision may be made vertically down from the anterior superior spine, between the tensor fasciae femoris on the outer, and sartorius and rectus femoris on the inner side. These muscles are retracted, the external circum-

flex vessels cut and tied, the capsule of the joint opened, and the head levered into positon. A pin may now be inserted through the great trochanter as before, or preferably a peg of living bone, cut from the crest of the tibia, used instead.

Of Extra-Capsular Type. Extra-capsular fracture of the neck in middle life may be treated by (*a*) *Extension.* This may be by means of a *pin through the os calcis*, to which is attached a metal stirrup from which a cord runs over a pulley to a weight. By this means a weight of forty to fifty pounds may be used at first. This is probably the method of election. As an anaesthetic is required in any case, impaction, if present, can be thoroughly broken down, and then if necessary the muscles may be overstretched by applying for several minutes as powerful traction as one is capable of. The limb is then placed in a position of extension and abduction, eversion being corrected, if present, by applying a weight to the inner end of the extension pin, or by the use of some form of foot bracket. The weight may be decreased after the first few days. Extension may also be applied by means of extension *straps* fixed to the limb by means of encircling strips of adhesive plaster. Overstretching of the muscles and breaking down of impaction necessitate the use of an anaesthetic. The projecting ends of the straps are fixed to a stirrup sufficiently wide to keep pressure off the malleoli, from which a cord runs over a pulley at the foot of the bed to a weight of twenty pounds at first. Eversion, if present, is corrected by use of a foot bracket or inverting side weight.

(*b*) *Splint. Long osteotomy splint* (q.v.) combined, if necessary, with active extension. The extension strapping is applied first to the full length of thigh and leg; the malleoli protected from pressure by pads, and the projecting ends of plasters attached to a stirrup. When the splint is ready and the fracture set, and the muscles preferably overextended as already described, the splint is slipped into position, the ends of the extension

plasters taken over either side of the foot piece to the stirrup, and the cord running over pulley to weight attached. The limb is then bandaged to the splint. It will be noted that the long osteotomy splint when properly fitted supplies a considerable degree of passive extension. Active extension should only be used when there is difficulty in keeping the sole of the foot applied to the footpiece or when the upper end of the splint is pressing unduly on the axilla.

A *Liston's long splint*, combined with extension, is often employed for this fracture. The extension is

FIG. 35.
Liston's long splint with extension.

applied by straps as already described, and then the splint, which should extend from the axilla to well beyond the foot, is prepared by wrapping several turns of a broad binder round that part which will come opposite the trunk, and several turns of a sheet round that which will come opposite the thigh and leg, taking care that the sheet will extend from the fork to near the ankle. The splint is then placed in position, the binder taken round the body and pinned firmly in position, and the sheet similarily taken round the thigh and leg and fastened by special pins to the portion previously wrapped round

the splint. The pins are so inserted as to lever the sheet down as each is inserted, thereby rendering the sheet very firm and tight. The sheet may also be fixed to the splint by strong drawing pins or carpet tacks. A foot bracket applied to the lower end prevents eversion.

Liston's long splint is also used for fractures of the shaft of the femur about the middle third. In this case the method is the same, except that, before applying the splint, four long pieces of gooch, padded, are applied to the thigh, in front, behind, and on either side, the pieces being fixed in position by three double ties encircling the limb.

Fracture of the neck of the femur rarely occurs in *young persons.* When *incomplete* it gives rise to slight eversion with diminished prominence of the great trochanter which is also slightly above Nelaton's line. There is difficulty in abducting and to a less extent in flexing and inverting the thigh, but patient may be able to walk. *Treat* by bringing the limb in to full abduction under an anaesthetic, and fixing it so in plaster of paris. The plaster is removed at the end of a fortnight, and replaced by extension, and massage and passive movement are begun.

Fracture of the great trochanter occurs very rarely from severe direct violence : still more rarely it may be *separated as an epiphysis* before the seventeenth year. If the fibrous tissues remain intact there may be little or no displacement, but, if they are ruptured, displacement may be considerable. There is inability to use the limb on account of pain, and the fragment may be palpable, if not masked by swelling. *Treatment* is by operation and fixation. Where there is no displacement, place limb in abduction and begin massage at once and passive movement after a fortnight.

Fracture of the lesser trochanter is slightly less rare, and it may also be *separated as an epiphysis.* The cause may be direct or muscular violence, and the fragment is displaced upwards. There is sharp pain and walking may be difficult or impossible. There is local

tenderness and difficulty in flexing the limb. *Treatment* consists in rest in bed with the limb flexed at hip and knee.

Fractures of the Shaft of the Femur. These are common in children but occur most frequently in middle

Fig. 36.—Lateral view of fracture of femur in upper third. (Dotted lines indicate insertion on other side of bone.)

Upper Fragment strongly flexed and abducted by A Ilio-psoas and D Gluteus max. E Gluteus medius. F Gluteus minimus.

Lower Fragment drawn up and inwards by Hamstrings and Adductors (G Adductor magnus) and everted by Adductors and Weight of limb.

life. They may be due to direct violence, when the line of fracture is usually transverse, and the displacement often slight; or they may be caused by indirect violence when the fracture is generally oblique from above and behind, downwards and forwards, or spiral. In

these latter the displacement and shortening are often considerable, and the fracture may be comminuted or compound. The middle third is most often affected. Swelling of the knee joint, possibly from sprain at time of injury, occurs occasionally, particularly when the fracture is in the lower third and due to indirect violence.

Fractures of the shaft are classified according as they occur in the upper, middle or lower third.

Upper Third. This is the least common and occurs more often in older persons, as the result of indirect violence, the fracture being most often oblique or spiral. The upper fragment is flexed and slightly abducted by the ilio-psoas and glutei. The lower fragment is drawn

FIG. 37.
Author's double inclined plane with adjustable foot piece.

upwards and inwards by the hamstrings and adductors, and is everted by the adductors and weight of the limb.

Treatment. In this fracture, as the upper fragment is short and not easily controlled, the limb must be brought into the position of flexion which it assumes. If a splint be employed some form of inclined plane must be used, such as a double inclined plane of wood; a Macintyre or a Hodgen, or one of its modifications.

Double inclined plane. A splint is chosen whose thigh piece extends from the gluteal fold to the knee. The angle at the knee should be adjusted so as not to be too acute, as otherwise it tends to interfere with the circulation. The foot piece should be pushed to the lower end of its slot until after the limb is in position. The splint is now padded with tow, well teased out, and covered with lint. The angle of the knee requires

specially careful padding. If it be thought necessary to bandage the padding in position do so with a gauze bandage.

As a rule this fracture requires to be set under an anaesthetic and the padded splint should then be slipped into position so that the flexed position of the thigh is maintained after setting. It is generally advised that the leg should first be bandaged from foot to knee to prevent oedema. The thigh should lie firmly along the thigh piece, and the knee should correspond to the angle of the splint, the leg lying along the lower limb of the angle. The thigh is fixed in position by a piece of gooch cut to fit, which should extend from below Poupart to about an inch above the condyles of the femur. Its breadth should be such that it does not touch the splint on either side. This gooch is padded with lint and fixed by means of three double ties. If preferred three strips of gooch may be used instead of the single piece. The foot-piece is now slid up to meet the foot, and is adjusted so that the foot lies almost at right angles to the leg in its position of flexion. A pad of lint is inserted between the sole of the foot and the foot-piece and the foot and leg are next bandaged to the splint. Finally, sandpillows are applied to either side, fixing the foot-bracket so as to prevent wobbling of the splint, and then a single blanket, cage, and sheet with other blankets, are placed in position in order named.

Should extension be required in addition, extension straps should be applied to the limb before the splint is applied, extending from the top of the thigh to the knee, and projecting beyond it. These plasters are carried to a stirrup from which a cord runs to a pulley placed high up, to correspond with the axis of the flexed thigh.

The foregoing description also applies to a *Macintyre*, with the following additional details. In preparing a Macintyre first fix on at the upper end the proper thigh-piece—right or left, according to limb—and adjust it

to proper length and then clamp in position by screws. The upper end should reach to within a finger breadth of the gluteal fold. After sliding foot-piece as far out as it will go insert a fold of lint through the slots in which

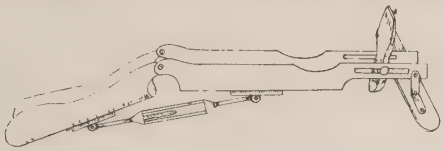


FIG. 38.
Macintyre splint without interchangeable thigh pieces.

the foot-piece slides and, after limb is in position, with heel resting on this piece of lint, bring the ends of the lint up over either side of foot, adjust foot-piece as already described, and then bandage whole in position.

When splints such as these are used, care must be taken that the circulation is not unduly impeded at the knee, and to obviate this danger many prefer a splint in which, while the thigh is flexed, the leg is kept horizontal. This may be done by a modified inclined plane

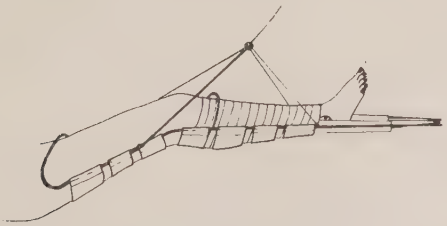


FIG. 39.
Hodgen splint with extension and suspension.

or by a Hodgen. *Hodgen's splint* resembles a modified Thomas'. Instead of a ring at the upper end, there is only a half circle, which lies in front of the limb, while a similar half circle in front below the position of the knee, strengthens the splint. Unlike Thomas', however, it is bent at the knee, and there are two hooks on either

side by which it may be suspended. It is prepared by applying a series of loops of stout calico or canvas to one of the side bars which, when finally attached to the other bar, serve to support the limb in the flexed position. Extension straps are applied to the thigh and leg as in the Thomas' ; the splint is placed over the front of the limb and held there while the loops of calico are brought round the back of the limb, and fixed temporarily to the other bar, thus supporting the limb. The extension is now fixed to the lower end of the splint, the loops of calico adjusted and fixed, and then limb and splint are suspended by means of cords running from the upper and lower pair of hooks to a stout brass ring, each cord passing through the ring to the corresponding hook on the other side. The ring is attached to an adjustable catch, which in turn is attached to a cord which runs over a pulley on a strong vertical support at the foot of the bed.

This fracture may also be treated by *extension* by means of *straps* or a *pin through the os calcis*. As a rule, even when the heavy os calcis extension is employed, it is not desirable to have the limb straight, on account of the tendency to flexion of the upper fragment. This may be overcome by propping the patient up, or by raising the limb. One of the simplest methods of raising the limb is to fix a wooden pole above the bed by supports attached to the top and bottom. The limb is suspended from this pole in the flexed position by means of slings of calico, and the extension cord runs over a pulley placed high up on the vertical support at the foot of the bed. It is seldom necessary to provide special abduction as the extension draws down the pelvis on the affected side and so places the limb in abduction in relation to the pelvis. It is comfortable for the patient, permitting a degree of movement ; is easily applied and quickly adjusted.

Extension may also be applied from the knee, with the limb in the flexed position, by means of *pins driven*

into the condyles, or by *calliper extension* in which the points, introduced through punctures through the soft tissues, rest against and pull upon but do not penetrate the condyles. In conjunction with the extension a splint of the Hodgen type is generally employed.

FIG. 40.—Lateral view of fracture of femur in middle third.

Upper fragment slightly flexed and abducted by ilio-psoas and Glutei.

Lower fragment drawn up by hamstrings and adductors (G adductor magnus) and everted by adductors and weight of limb.

Fracture of the middle third of the femur is the most common of the three, particularly in children.

If due to direct violence and transverse there may be comparatively little displacement, but when spiral or oblique the upper fragment tends to be flexed and

abducted by the ilio-psoas and glutei, while the lower tends to be drawn up by the long muscles, and everted by the adductors and weight of limb.

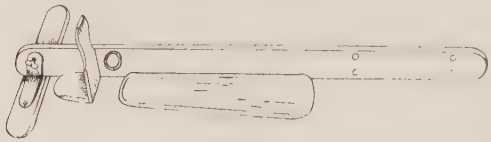


FIG. 41.
Long osteotomy splint and foot bracket: side view.

Treatment. As the upper fragment in this case is long and comparatively easily controlled, the limb is put up straight in splint or extension.

FIG. 42.
Long osteotomy splint padded and ready for application: viewed from above.

Long Osteotomy Splint. Two measurements are required (1) length from axilla to sole of foot corresponding to length of side piece of splint down to foot-piece and (2) length from finger breadth below gluteal fold to sole of foot corresponding to length from top of back-

board to foot-piece. The splint is padded with tow, covered with squares of lint; a pad of lint is placed on foot-piece; a long bran pillow is placed along the side of side-piece, extending below from seat of fracture to beyond upper end of splint, at which place it is turned over the end so as to pad it and prevent injury to the

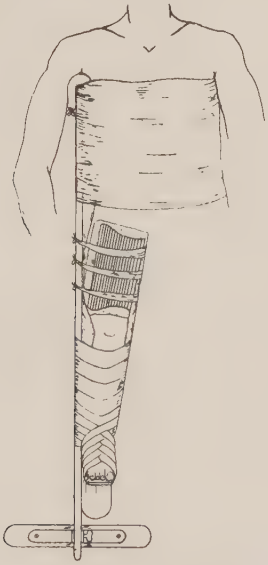


FIG. 43.
Long osteotomy splint applied: viewed from above.

axilla. This bran pillow is fixed in position by means of single ties passed through holes in the side-piece, and which are cut long so as to go round body when splint is fixed in position.

The fracture having been set, the splint is slipped into position, and an assistant holds the sole of the foot firmly applied to the foot-piece, while the operator fixes the thigh by applying a piece of gooch cut to shape

and padded with lint which is held in position by means of three double ties. The gooch is cut parallel to the groin at the upper end, and should extend from just below the groin to two finger breadths above the patella. Its breadth is such that it encircles the exposed part of the limb, but does not touch either board of the splint. The thigh having been fixed, the heel and external malleoli are padded with small bran pillows, and then the foot and leg are padded with lint and bandaged to the splint by calico bandage, extending from above the toes to just below the knee. Finally, the ties holding the long bran pillow in position are passed round the body and tied, lint padding being placed between them and the skin, and, if necessary a binder may also be applied over the ties. A foot-bracket is applied to lower end to prevent eversion, sand-pillows placed on either side, and then the single blanket, cage, and finally other bedclothes are placed in position. It will be noticed that, if this splint be properly fitted, it supplies a passive extension, which is generally sufficient to keep the fragments in position. If necessary, however, extension plasters may be put on before splint is slipped into position, the ends of which project on either side of the foot-piece and are attached to a stirrup from which cord runs over pulley to weight. A *Liston's long splint* with or without extension may also be employed (see p. 134).

Extension alone is applied as already described (p. 20), either by strapping or pin through os calcis. An inverting pull may be necessary, but is generally obviated by use of a weight on inner end of pin or simple foot-bracket.

Fracture of the lower third of the femur is intermediate in frequency, and occurs more often in adults than in children. The fracture is generally transverse when caused by direct violence, but when due to indirect violence it is oblique from above and behind, downwards and forwards, or spiral, the spiral generally being a short one. In the oblique and spiral forms the lower

fragment tends to be tilted backwards by the gastrocnemius, and may exert injurious pressure on the vessels.

Treatment. When transverse this fracture may be put up straight on the long osteotomy splint; when oblique on an inclined plane or Hodgen. The circulation

FIG. 44.—Lateral view of fracture of femur in lower third. Lower fragment tends to be tilted backward by H gastrocnemius, and to be drawn up by long muscles.

must be carefully watched before and as long as the splint is in position.

Where the lower fragment is short and tilted backwards, it is difficult to correct the position by splints, and extension sometimes tends to increase the tilt. In such cases *operation and plating* is generally best through an incision on the outer side.

All *fractures of the femur in children* can generally be successfully treated by applying *vertical extension* to both limbs. The plasters are applied as already described, and the cords from the stirrups are carried to pulleys placed vertically above the buttocks. The weights should just be sufficient to slightly raise the buttocks from the bed. Thick rubber tubing may be used instead of the weights and pulleys. Most hospitals have special apparatus for this form of treatment but a makeshift is easily improvised of wood, particularly if the child be placed in a crib with high sides.

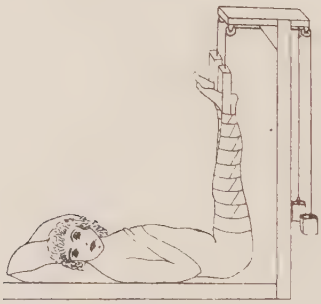


Fig. 45.
Vertical extension for fractured femur.

Subsequent Treatment. With the exception of the intracapsular type, where the patient is generally old and unable to remain long in bed without harm, all fractures of the femur are kept up for from six to eight weeks, massage being given from the outset and passive movement after two weeks if the apparatus will permit. The treatment is not then complete. The splint or other apparatus having been removed and the bone found to be firmly united, massage, passive and active movements are given, and a pillow is placed under the knees to flex the joints. Thereafter the patient may be allowed up, crutches, and a patten on the sound foot

being used. Generally it is wise to apply a light plaster of paris splint for a few weeks after the patient gets out of the splint, at least until he can manage the crutches properly, as the bone may easily be refractured by a fall. One hundred days is generally considered to be the time necessary for the complete treatment of a fractured femur, particularly by splints.

Fractures of the lower extremity of the femur. *Separation of the lower epiphysis* may occur up to about twenty years of age, due generally to hyper-extension of the knee. The epiphysis is generally displaced forwards and upwards and tilted so that the fractured surface rests against the front of the shaft. The lower end of shaft may project through skin laterally or posteriorly, rendering condition compound. The condition may be masked by swelling and the joint is generally distended with fluid, in which cases an X-ray may be of assistance in diagnosis. Where there is no displacement diagnosis is difficult.

Treatment. Attempts must be made to reduce the displacement if present, but sometimes reduction even by operation is difficult. Massage and passive movement should be commenced early, and displacement is not likely to recur on account of the broad surfaces involved.

A *single condyle may be separated*, or a T or Y fracture may cause separation of both condyles. The cause is generally severe direct violence, but T and Y fractures may be caused by impaction of the shaft causing splitting of the condyles. The joint of course is involved and is generally distended with effusion; the vessels may be damaged, and the fracture may be compound. Where the fracture is of the T or Y type the knee appears unduly broad, while, if a single condyle be involved a genu valgum or varum may appear to be present.

Treatment may be by operation, the joint being opened and accurate apposition secured. If for any reason this

be impossible then treatment may be by extension and application of elastic pressure to knee-joint and condyles, aspiration being performed if necessary. Attempts may also be made to keep the condyles together by lateral approximating pulls from weights over sides of bed. A Hodgen splint is sometimes used. Gangrene may supervene on severe injury to the vessels and necessitate amputation.

Patella.

This bone is generally fractured by muscular action, the fracture being transverse, and as a rule situated about the centre of the bone or below it, but it may also be fractured by direct violence, the fracture being oblique or stellate.

The *transverse fracture due to muscular action* is generally produced by violent action of the quadriceps as when the patient trying to save himself from falling backwards, pulls the patella upwards by the action of the quadriceps, the knee being somewhat flexed and snaps it on the prominent condyles of the femur. The action may be compared to snapping a stick over the knee, save that the action takes place in the vertical direction, one end of the patella being held by the ligamentum patellae and the other by the quadriceps. It follows therefore that the fragments are tilted at the time of fracture, the fractured surfaces being directed forwards, while the separation is greater in front than at the posterior articular surface. The portion of quadriceps aponeurosis covering the front of the bone (the patella has, of course, no periosteum) is stretched and torn, and, owing to the tilting of the fragments may be brought forcibly into contact with and adhere to the fractured surfaces. Thus after the fracture has occurred and the relaxation of muscular effort permits of the fragments regaining somewhat their normal position, the aponeurosis is folded in between the broken surfaces and separates them, rendering osseous union impossible. The knee-joint is involved,

and is often distended with blood from the vascular bone. The prepatellar bursa being situated rather below the usual line of fracture may escape. The amount of separation of the fragments varies, depending largely upon the extent to which the lateral expansions of the quadriceps aponeurosis have been torn, the damage to these often being increased by attempts to rise or use the limb after the accident.

In *fractures due to direct violence* the aponeurosis generally remains intact, and the fragments are not markedly separated.

FIG. 46.

Transverse fracture of patella showing position of fragments and torn aponeurosis immediately after fracture. A, aponeurosis; B, Quadriceps; C, Ligature Patellae.

Symptoms. The diagnosis is often easy, the characteristic history of injury and the appearance of the two fragments with a sulcus between making the condition obvious. Frequently, however, the haemarthrosis of the knee is so marked as to mask the condition of the patella, while in some cases of oblique or vertical fractures an X-ray may be necessary to confirm.

Treatment depends upon the type of fracture. If it be transverse with rupture of aponeurosis, and osseous union

is desired, an *operation* must be performed to remove the aponeurosis intervening between the fragments. A horizontal, curved, or vertical incision may be used. The fragments are exposed, and the aponeurosis removed from the fractured surfaces to which the adhesion is sometimes so firm that an elevator is necessary to detach it. Fluid and blood clot should be carefully removed from the joint, and then the fragments should be drilled, taking care not to perforate or damage the cartilaginous surfaces, and brought together by silver or soft iron wires or perferably by stout catgut passed through the holes and tied.

The best method of drilling the patella is to make two holes from side to side, one through the upper end of the upper fragment, and the other through the lower end of the lower fragment. If wire be used, two U-shaped pieces should be employed, the limbs of the one U being inserted through both holes from one side, and those of the second from the other side. The free ends of the U's are then twisted together on either side, and the fragments held firmly in position. It is of the greatest importance to see that, as the fragments are adjusted, no fragments of aponeurosis or other soft tissue are allowed to intervene. The aponeurosis is next sutured over the surface of the bone, the tears in the lateral expansions stitched, and the wound closed.

The limb is then placed on a posterior splint, and massage, particularly of the quadriceps, is begun at once, and passive movement of the joint after a week.

Where this type of fracture is not operated on, the result is fibrous union, and while this may look strong at the time, it is always liable to stretch, particularly if the patient uses the limb freely, so that the fragments gradually separate, and the limb is greatly weakened. If such cases desire *operation subsequently*, it is generally necessary to open up the parts freely ; detach the upper fragment from the femur if it has become adherent, and also detach the quadriceps which not infrequently has

become bound to the femur just above the patella by a mass of fibrous tissue. If, after so doing, the upper fragment does not come down freely, it may be necessary to drill the fragment and pass wires through it by which extension may be applied for a time. The subsequent operation is that already described.

In *old persons*, where operation is not desirable, swelling of the joint should be reduced, if slight, by elastic pressure and massage, or, if great, by puncture with trocar. The limb is put up on a back splint or short osteotomy splint (p. 153), and the patient propped up in bed so as to relax the quadriceps and thus help to approximate the fragments. Massage is begun at once and the patella moved slightly laterally, in one piece. Passive movement is begun after a fortnight. After six weeks the patient may be allowed up on crutches, and should wear a support for the knee, for a short time.

Stellate or oblique fractures are treated in the same manner as fractures in old persons, passive movement being commenced after a week.

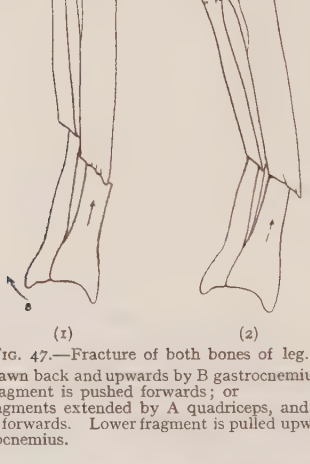
Leg.

Fracture of both Bones of the Leg may be due to direct or indirect violence. When due to *direct violence* both bones break about the same level, the fibula often slightly higher up than the tibia. The fracture is often transverse, and the displacement slight. When due to *indirect violence*, the tibia generally fractures about the junction of the middle and lower thirds and the fibula higher up. The fracture of the tibia may be oblique from above and behind downwards, forwards and inwards, but, owing to torsion—the foot fixed by contact with the ground, while the body and limb are rotated—it is often spiral, while a portion may be separated, and long fissures, possibly implicating one of the joints, may co-exist.

The lower end of the upper fragment tends to project forwards from the action of the quadriceps, while the

lower fragment tends to fall backwards and to be pulled up behind the upper by the gastrocnemius, while it is rotated outwards by weight of the foot. Not infrequently, however, the action of the gastrocnemius is to pull the heel up, pointing the toes, and tilting the lower fragment so that its upper extremity projects forwards and may perforate the skin.

This fracture is *particularly often compound*, due to the superficial position of the sharp tibial crest, and the



(1) (2)

Fig. 47.—Fracture of both bones of leg.

(1) Heel is drawn back and upwards by B gastrocnemius and so upper end of lower fragment is pushed forwards; or

(2) Upper fragments extended by A quadriceps, and so lower end tends to project forwards. Lower fragment is pulled upwards and backwards by gastrocnemius.

tendency of both broken fragments to project forwards. The vessels and nerves generally escape injury.

Diagnosis is generally easy from deformity, abnormal mobility, crepitus, and palpation of the fracture. When near the knee-joint, however, and masked by swelling, X-ray examination may be necessary.

Treatment may be by *short osteotomy splint.* This resembles the long osteotomy splint (q.v.) except that the side board is of the same length as the back board and

does not extend up to the axilla. The back board should come to a fingerbreadth from the gluteal fold when the sole is resting on the foot-piece. The splint is padded with tow, over which pieces of lint are placed, the foot-piece being also padded with lint. If the fracture is in the lower third, the space at the heel should be bridged over with a piece of wood, and small bran pillows placed as padding both for heel and for external malleolus.

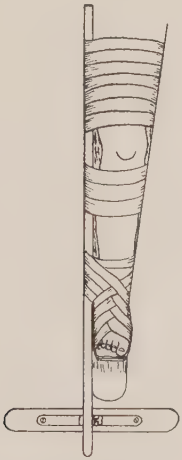


FIG. 48.
Short osteotomy splint applied. Viewed from above (padding on front of limb omitted).

The fracture having been set, under an anaesthetic if necessary, the limb is placed in the splint, and the alignment of the limb is carefully adjusted—the inner edge of patella, the internal malleolus, and ball of great toe all being in line. Strips of lint are next placed over the front of the limb, the first extending from dorsum of foot to point of fracture, the second from point of fracture to below the knee, and the third from above knee to upper end of thigh.

The limb is now bandaged in position with calico bandages, the first running from the foot to near point of fracture of tibia which is not covered in ; the second from above fracture to below knee, which is also left exposed, and the third running from above knee to upper end of splint. The foot-bracket is next fitted, sand-pillows placed in position on either side ; single blanket, then cage, and finally rest of bedclothes placed on top.

The point of fracture is not bandaged in but left exposed, so that the skin, which, even when not perforated, has often been damaged, will not be subjected to pressure, and may regularly be bathed with spirit.

Another splint which may be used in the treatment of fracture of both bones is the *Edinburgh box-splint.* It consists of three pieces of wood, a quarter of an inch thick, and four inches wide, which extend from above the knee to beyond the foot. A sheet is taken and folded, and one of the boards padded with tow or cotton wool is slipped in between the folds of the sheet at the centre which is now adjusted to the limb so that the limb rests on the padded board. The other two boards are now rolled in the sides of the sheet until they meet the central board and stand at right angles to it, the sheet forming hinges. A ring pad is placed under the heel, and padding placed in the lateral intervals between limb and splint, which is fixed in position by means of three ties. The splint is easily undone for massage and passive movement.

Cline's splints are also sometimes used, or the limb, after having been kept at rest between sandpillows until the swelling has subsided, may be put up in *plaster of paris* bandages, a layer of thick flannel bandage or of cotton wool, or a thick stocking being first applied next the skin. The plaster splint should include both knee and foot and later the patient may walk with the aid of a stick, the plaster splint being retained.

Fractures of both bones may also be treated by *plaster extension*, but where the fracture is near the lower extremity of the bones, the heel tends to drop and this

must be corrected either by combining the extension with a splint or by applying a vertical extension to the foot by means of a loop of adhesive plaster, one limb of which extends down along the sole and so round the heel posteriorly and up to the ankle, while the other extends along the dorsum of the foot to the ankle in front. This plaster should be held in position by several narrow encircling strips. The free loop beyond the toes is then attached to a vertical extension. Extension by *pin through the os calcis* avoids this difficulty and is more efficient.

In some cases, and particularly where the fracture is spiral, good apposition is difficult with a splint or even with extension, and in such cases, as well as in many cases of compound fracture, the fracture is best dealt with by *operation*. If a plate is employed it is generally well not to place it on the superficial surface of the tibia, on account of the probability of subsequent trouble, but on the outer surface under cover of the muscles. The tibia is particularly suited for fixation by two plates on opposite sides secured by bolts.

Splints or extension should be retained for about *four weeks*, after which a light plaster splint may be applied and the patient allowed to get about on crutches. If the plaster casing is split down both sides, it can be easily removed for massage and passive movement, and re-applied by means of ties.

The *supra-malleolar fracture of Malgaigne* occurs about one and a half inches above the ankle, and is generally due to indirect violence, the foot being rotated in or outwards, but is sometimes due to direct violence. The fracture may be transverse, or short spiral, but sometimes it is comminuted and the fibula may break about the same level.

There is generally marked swelling over the affected region while the displacement may simulate backward dislocation of the ankle. Pain at the site of fracture, abnormal mobility and crepitus may help to distinguish, but an X-ray may be necessary.

Treatment by operation may be required, but extension or a splint may be tried. If the latter, the short osteotomy with the gap for the heel bridged should be employed.

Fractures of the Tibia alone.

Fractures of the upper end are not common. A few cases of fracture of the tibial spine, in association with supposed sprains or twists, producing inability to fully extend the knee-joint have been recorded. A transverse fracture of the upper end, due to direct violence; and impaction of the shaft into the cancellous tissue of the head from a fall on the feet have been met with. Fracture of one of the tuberosities may be caused by a fall, or rarely a blow, and is followed by haemarthrosis of the knee which may necessitate treatment by aspiration or puncture.

Separation of the upper epiphysis is very rare. Partial separation of the epiphysis, involving the *portion for the tibial tuberosity*, is more common. It is caused by powerful muscular action, and is followed by swelling and considerable pain, with difficulty in actively extending the knee fully. *Treatment* is by pressing the portion into position by means of a band of adhesive plaster, like a garter, while the knee is kept extended on a splint for four or five weeks. In later life the tuberosity may be partially or entirely separated in a similar manner, displacement being upwards in the complete variety, necessitating operation and fixation.

Fractures of the shaft are generally due to direct violence, and are transverse, in which case, the fibula acting as a splint, little or no displacement may occur, the patient sometimes being able to walk on the affected limb. These cases may generally be *treated* without a splint, the limb being placed between sandpillows, and massage and passive movement regularly given.

Sometimes from direct violence and generally from indirect violence an oblique or spiral fracture is produced,

and in these cases extension, or a short osteotomy splint, may be applied.

The **V**-*shaped fracture of Gosselin* occurs most frequently in the lower third of the tibia. It consists of (*a*) a very oblique fracture of the tibia from above and behind downwards, forwards and inwards. The lower fragment presents therefore an inverted **V**-shaped projection above and posteriorly, and a **V**-shaped depression in front and to the inner side. (*b*) From the apex of this depression a spiral fracture runs down and backwards to the ankle joint, and may detach an inverted **V**-shaped piece of bone from the posterior surface.

Fig. 49.
V-shaped fracture of Gosselin.

The *lower epiphysis* of the tibia is occasionally separated and displaced with the foot outwards or backwards, generally from indirect violence applied to the foot, such as hyper-extension, flexion, or rotation. It occurs usually during adolescence. A portion of the outer side of the shaft may be detached along with the lower fragment, while the fibula may also be fractured, or its epiphysis separated. It is not infrequently compound. There is marked deformity, swelling, abnormal mobility and soft crepitus. Rarely the growth of the tibia is arrested and the continued growth of the fibula causes inversion of the foot.

Treatment. Reduction by manipulation, while extension and counter-extension are kept up with the knee in flexed position, is difficult, and operation may be necessary.

Fractures of the Fibula alone.

Fractures of the upper extremity and separation of the upper epiphysis are rare.

Fracture of the shaft about the upper third is generally due to direct violence, but may occasionally be caused by inward rotation of the trunk and thigh while the foot

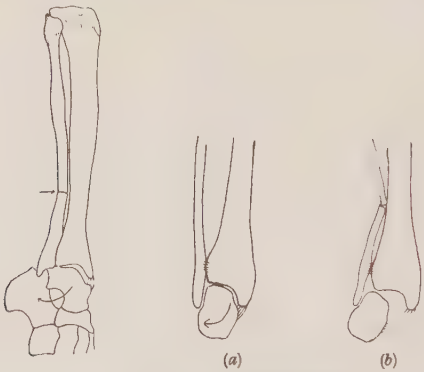


FIG. 50.—Pott's fracture.

As astragalus moves outwards it (*a*) pulls upon and tears the internal lateral ligament and (*b*) presses on external malleolus, levering it out and so pushing shaft above the tibio-fibular ligaments inwards till it breaks 2-4″ from lower end.

is fixed. The internal lateral ligament gives way or the internal malleolus is broken, and the foot remains in a position of dislocation outwards. The condition of the foot may distract attention from the high fracture of the fibula which may be overlooked in consequence.

Fracture of the fibula high up may also rarely occur from falls from a height, the astragalus being wedged up between tibia and fibula, with tearing of the inferior

tibio-fibular ligaments, and separation of the bones at the ankle. The external popliteal nerve or its branches may be damaged in fractures of the upper third. *Treatment* of these fractures is by extension and massage: where an eversion dislocation of the foot exists, this must be corrected.

Pott's fracture is one of the most common fractures and, as there are several varieties, the typical form will first be described and then the varieties noted. The fracture affects the fibula two to four inches from its lower end, and is due to indirect violence, the foot being forcibleeverted and somewhatrotated outwards(abducted). As the astragalus moves outwards it pulls upon and tears the internal lateral ligament, or, if the ligament remains intact, the internal malleolus gives way, generally about its base. The astragalus next presses against the external malleolus, and, the inferior tibio-fibular ligaments remaining intact and acting as a fulcrum, the fibula above the ligaments is forced inwards until it breaks, often spirally or obliquely, both fragments being displaced inwards by the fracturing force.

Where the fracture is caused by *eversion alone*, the internal malleolus breaks off square at the base; the tibio-fibular ligament is ruptured, or the portion of tibia to which it is attached avulsed, and the fibula fractures transversely just above the malleolus.

Where the fracture is due to *abduction alone*, the anterior portion of the internal lateral ligament is ruptured or the anterior portion of the internal malleolus avulsed, the tibio-fibular ligament may possibly be ruptured, and the fibula fractures obliquely three to four inches from its lower end.

Pott's fracture with inversion of the foot is the result of reversal of the ordinary mechanism, and is much less common. The external malleolus is broken across the base, or, in young persons, along the epiphyseal line. The internal malleolus is fractured across the base or still higher up. The foot is inverted, displaced back-

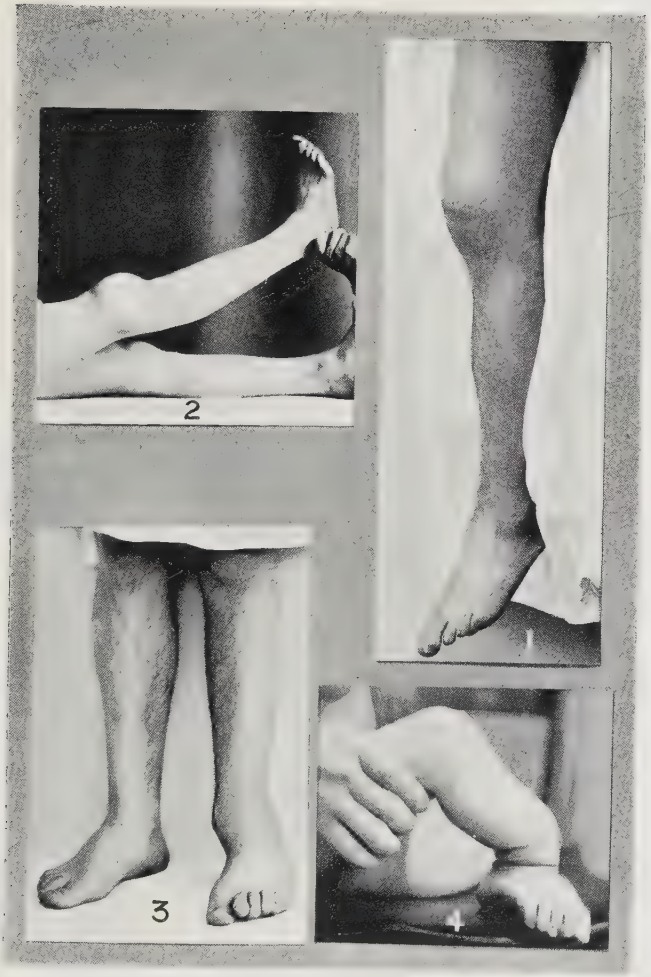
wards, and the toes are pointed. Treatment as for Pott's fracture but mechanism reversed.

Dupuytren's fracture is the name applied to a condition, generally due to great violence, such as a fall from a height, in which the inferior tibio-fibular ligaments are ruptured, or tear off a portion of the tibial insertion by the wedging action of the astragalus, which is sometimes driven up between tibia and fibula. The fibula breaks as before.

Symptoms. In typical cases the diagnosis is generally easy. The foot is everted—the outer border being raised —and displaced backwards, the condition amounting to a semi-dislocation of the foot. On the outer side there is a depression over the seat of fracture, while the external malleolus is unduly prominent, and on the inner side the internal malleolus is unduly prominent, and has a depression immediately beneath it. In those cases where the internal malleolus has been torn off, the lower end of the upper fragment is often very sharp and may easily cut through the skin which is stretched over it. Where the deformity is not marked, this sharp margin is often easily detected by palpation, while rocking of the lower fragment of the fibula may be elicited by alternate pressure on its upper and lower extremity. Pain and tenderness on pressure are generally marked over the point of fracture of the fibula, and crepitus may be elicited by rotation of the foot.

Treatment. Where there is little or no deformity, or where, the deformity having been reduced, it does not tend to recur, the limb may be placed between sand-pillows, massage given at once, and passive movement begun after a few days. Later, active movement, while the ankle is carefully supported by the hand, should be attempted.

Where reduction of deformity is necessary it is best done by applying extension and counter-extension while the knee is flexed, and the operator inverts and adducts the foot.



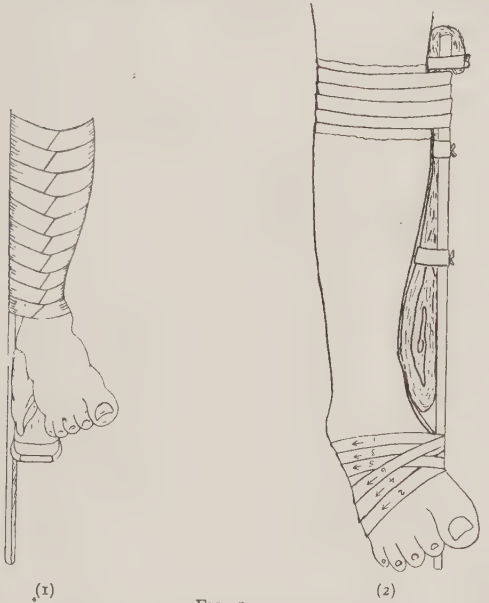
(1) Transverse fracture of patella showing sulcus between fragments (no haemarthrosis).

(2) Transverse fracture of patella with haemarthrosis—no sulcus seen.

(3) Old malunited Pott's fracture of fibula.

(4) Congenital fracture of both bones of leg.

Where there is a tendency to displacement, the fracture may be treated *by extension*, with, if necessary, a vertical pull on the foot to correct backward displacement, or by a splint. The *short osteotomy splint may* also be used, with the space at the heel filled in and a large bran pillow



(1) (2)

FIG. 51.

Pott's fracture treated by (1) Short osteotomy applied to the outer and (2) Dupuytren's applied to inner side of leg. Both produce marked inversion of foot by which fragments of fibula are forced back into their places.
(1) by pad below external malleolus and bandage above ankle.
(2) „ „ above internal „ „ below „
Both support heel, (1) by splint, (2) by bandage.

placed *below* the *external* malleolus, along the outer border of the foot. The bandage begins above the ankle and is carried up to the knee. As it is applied the foot is forced into a position of inversion, and so tends to keep the fragments in position, while backward displacement

is prevented by the filling in of the space behind the heel. It is not necessary to bandage the foot to the footpiece, and it is better not to do so as then movements of the foot can be carried out.

Dupuytren's splint is applied to the inner side of the leg and the mechanism is therefore reversed. It consists of a straight splint with a hole at the upper end and three prongs at the lower. It may be simply padded by a folded towel laid along the surface next the skin, the lower end of which is rolled up to form a large pad, which must come *above* the *internal* malleolus. The end of a two and a half inch calico bandage is pushed through the hole at the top and knotted so that it will not slip out again, and then the bandage is carried over the upper end of the splint, and down over the surface of the towel to the lower end where a turn is taken round one of the projecting prongs. This bandage is used to bandage the foot and ankle. Towel and bandage are held in position by three strips of bandage tied round them and including the splint.

The splint is now applied to the limb, the upper end coming almost to the knee, and the prongs projecting beyond the foot, while the pad is carefully adjusted so as to come down to, but not beyond, the internal malleolus. The bandage is then applied in a figure of eight round the foot and heel alternately, raising the heel and markedly inverting the foot and going through one of the slots between the prongs each time, care being taken not to go above the external malleolus. A turn of bandage round the splint and limb just below the knee completes the application. The limb may rest on a pillow with the knee flexed.

Subsequent treatment. Whatever splint is used it may be removed after about a fortnight, and the limb placed between sandpillows and massage and passive movement given. Thereafter a plaster casing extending to the knee may be applied and the patient allowed to go about, using the limb, but with the aid of sticks or crutches.

The plaster may generally be removed after four or five weeks from the time of fracture.

The *lower epiphysis of the fibula* may be separated by direct or indirect violence such as twists of the foot. After reduction treatment may be by elastic bandage, resting the limb between sandpillows, and massage and passive movement being begun early, but operation may be necessary.

Bones of the Foot.

Fracture of the **astragalus** may be due to direct or to indirect violence such as falls on the foot from a height or severe twists of the foot. Sometimes the fracture runs through the neck and sometimes it is comminuted. Pain and swelling are marked, the latter frequently masking crepitus. An X-ray examination is of assistance.

Treatment. Where the parts are in good position elastic pressure with massage and passive movement may be sufficient, care being taken that the toes are moved regularly, particularly the great toe, as its tendon runs in a groove in the bone. In other cases operation with excision in whole or part may be necessary.

Sometimes a split may also be caused in the lower end of the tibia, running generally upwards and inwards. Anchylosis of the ankle is apt to follow these injuries. Care must be taken not to mistake an os trigonum at the posterior aspect of the astragalus for a fracture, but a few cases of fracture of the process have been reported.

The **os calcis** is generally fractured by direct violence such as a fall on the feet the left bone being said to be more often affected. The fracture may be either transverse or longitudinal, and is frequently comminuted.

There is generally considerable swelling, and pain radiating up the leg. Crepitus can sometimes be elicited, but skiagraph may be necessary.

The posterior tuberosity may be detached by action of the tendo Achillis, associated with a fall on the heel.

Generally there is little displacement as the calf muscles are counteracted by the short muscles of the sole rising from the inferior aspect.

Symptoms and treatment. Sometimes, however, there is considerable separation of the fragments, and in such cases operation with fixation may be necessary. A metal pin or screw or preferably a peg of living bone cut from the tibial crest being used. Pain, swelling, discolouration, and inability to flex the ankle are the usual signs.

While some fractures of the os calcis may require setting under an anaesthetic, they may generally be treated by elastic pressure, massage and passive movement, but healing is often slow and the patient may be unable to use the foot for some months.

A few cases of fracture of the sustentaculum tali from forcible inversion of the foot are reported.

Fractures of the *scaphoid, cuboid and cuneiform bones* are generally due to severe direct violence, with laceration of the foot. The scaphoid alone, or along with the cuboid or one of the cuneiforms, may be fractured by falls from a height on the extended foot. The scaphoid tubercle may sometimes be detached.

The inner border of the foot is shortened in fractures of the scaphoid; there is pain on pressure on the great toe, and walking is difficult. Traumatic flat foot is apt to follow.

Treatment. Correction of the deformity may be attempted under anaesthetic and then the foot may be placed in plaster or in vertical extension, passive movement being commenced after ten days. Operation may be necessary. Weight should not be put on the foot for ten weeks after the injury.

Metatarsus and Phalanges.

Fractures of the **Metatarsal bones** are frequently due to direct violence, in which the foot is often much lacerated and amputation necessary. The anterior halves, particu-

larly of the second and third bones may be fractured by falls on the feet, while the base of the fifth metatarsal has been fractured, as in dancing, by the foot being brought down forcibly in a position of extension and inversion. (*Jones' fracture.*) There is pain on pressure, and on attempting to use or move the foot; swelling and ecchymosis. Confirmation by X-ray should be made.

Treat by elastic pressure and massage. No weight should be put on the foot for at least six weeks.

The **phalanges** are most often fractured by direct violence causing crushing of the part and often necessitating amputation. In other cases they may be treated by plantar splint. The sesamoid bones of the great toe may also be fractured, causing pain and swelling.

DISLOCATIONS

A **dislocation** is the abnormal and more or less permanent displacement of the articular portions of the bones of an articulation from one another. It may be partial (subluxation) or, where no portions of the articular surface remain in contact, complete. It may also be simple, compound, or complicated. Where the displacement is momentary and normal relationship is immediately restored the term *sprain* is applied.

All dislocations are not traumatic in origin: thus congenital, spontaneous, voluntary, and pathological forms occur. Spontaneous forms may arise from previous distension of the joint cavity or muscular paralysis. The power to voluntarily dislocate a joint generally follows upon a traumatic dislocation of the joint in question, but rarely, and especially in the hip, the patient has this power without previous traumatic dislocation.

In the ordinary traumatic types the *cause* is generally violence, either direct or indirect, or muscular action, and in many cases both causes probably act together. Even in these types, however, laxity of the capsule, due perhaps to previous rheumatic arthritis, or pathological changes in the joint or bones may be predisposing causes.

Symptoms. Whereas a fracture is characterised by preternatural mobility and crepitus, in a dislocation there is generally preternatural rigidity; absence of true osseous crepitus; and ability, as a rule, to retain position after reduction. Deformity is generally a marked

symptom. Pain is usually very severe, from stretching of capsule and muscles, and pressure upon nerves, which, in turn may cause numbness and temporary paralysis of the affected limb. Swelling and discolouration over the affected joint generally supervene.

Complications. Where the cause is violence the capsule is generally torn, and the head, emerging through the rent, may rupture some of the surrounding tendons and muscles, and contuse and press upon others, while even large vessels and nerves in the vicinity may be affected.

When muscular action alone is the cause, the capsule often remains intact but is stretched, the head remaining within the capsule.

Spontaneous *reduction*—without the intervention of intentional external force—occurs occasionally. A dislocation should always be reduced as soon after the accident as possible. Immediately after the injury the patient is often faint with pain, the muscles relaxed, and reduction therefore may be easy. As muscular action is often the cause of difficulty in reduction, it is of advantage to throw the patient off his guard when attempting reduction, as by asking a question, or requesting him to sit down. In some cases it may be necessary to tire the muscles before reduction. In many cases the intact portion of the capsule opposes reduction and necessitates certain manipulations in order to pass the dislocated head back through the rent in the capsule.

Where reduction has been repeatedly attempted and has failed, and the dislocation has been present for days or weeks, reduction becomes difficult, and may necessitate the use of an anaesthetic. Reduction has been repeatedly accomplished by manipulation after a dislocation has been present for several months, but in many such cases operation is necessary, and it is generally safer, as vessels or nerves are apt to be torn, emboli produced, and fractures caused, by the manipulations necessary.

(1) Bilateral dislocation of jaw.
(2) Unilateral ,, ,, ,,

When a *dislocation is not reduced*, the old socket becomes gradually filled up with fibrous tissue, while a new false socket of fibrous tissue or bone, according to the site, is formed for the head. The head generally loses its cartilage, and may be partially absorbed, while eburnation of opposing bony surfaces may occur. Sometimes a regular false joint with capsule and synovial fluid forms, and a useful and even powerful limb results. In many cases, however, atrophy of the muscles and even of the bone occurs, while nerves may be pressed on and their functions impaired. Vessels may similarily be pressed on and they sometimes become adherent to the capsule of the false joint and, as already mentioned, may be torn in attempts at reduction.

After treatment. In all cases, but particularly those where there is a rent in the capsule, the joint should be fixed in position for a week or ten days after reduction, only gentle passive movement being permitted during this period, while limited active movement is allowed thereafter. If this be not attended to, and the dislocation recurs, the rent in the capsule is apt to persist, and recurrence of the dislocation is then likely to be frequent.

Lower Jaw.

Dislocation of the lower jaw is more often bilateral than unilateral; occurs generally in early adult life, and particularly in females. It occurs most readily when the mouth is wide open, and may be due to muscular action, as in yawning, or to violence, such as the extraction of a tooth. It occurs readily when the muscles are relaxed, as from the use of a gag during anaesthesia. When the mouth is wide open the condyle, accompanied by the interarticular fibro-cartilage, rests on the articular eminence, and may be pulled forward by the action of the external pterygoid, after which the masseter and temporal muscles draw it up under the zygoma. Again, when the jaw is widely open, and the condyle rests on

the eminence, a blow on the jaw, particularly in a downward direction tends to force the condyle forwards, rupturing the capsule, or stretching it if lax.

In **bilateral** dislocation the mouth is open, and cannot be closed, although further opening is generally possible, and the jaw is projected forwards. There is a depression between the external auditory meatus and the prominent posterior margin of the condyle, while a fulness exists in the temporal fossa from bulging of the muscle. There is generally considerable pain; saliva trickles from the mouth, swallowing is difficult, and patient is unable to articulate, speech being guttural.

In the **unilateral** form the jaw deviates to the sound side, giving the face a distorted appearance, but sometimes the deformity is slight.

Reduction is generally easily accomplished by means of a cork, to act as a fulcrum, placed far back between the molar teeth. The chin is then pushed upwards (bringing the condyle from under the zygoma on to the eminence) and then backwards (returning it to the glenoid fossa). Where the dislocation is bilateral, and one side is done at a time, care must be taken not to redislocate the side first reduced while attempting the second. In some cases an anaesthetic may be necessary, and sometimes the result is best achieved by first depressing the chin fully and then pushing backwards, and closing the mouth. The success of this method is variously ascribed to disengaging of the coronoid process or to relaxation of the external lateral ligament: in any case it reproduces the position in which the dislocation occurred.

After reduction the jaw should be fixed in position for ten days by a four tailed bandage, and the patient must be warned to avoid opening the mouth widely for several weeks longer.

The condition is apt to become recurrent, particularly in epileptics. *Recurrence* has been successfully treated by suture of the interarticular fibro-cartilage to the

periosteum and by injection of irritants into the peri-articular tissues.

Where, from any reason, the *dislocation is not reduced*, the condition gradually improves so that the patient is able to close the lips and prevent trickling of saliva, and speech is fairly good. The teeth, however, do not approximate correctly, and mastication is very defective. Reduction has been effected even ten months after the accident, and repeated attempts made every two or three days are most likely to be successful in such cases. Operation may be necessary, sometimes with excision of the condyle.

A condition, described as *subluxation of the lower jaw*, occurs rarely, generally in young persons, and is variously ascribed to laxness of the capsule, undue mobility of the interarticular fibro-cartilage, or jamming of the condyle in front of the interarticular cartilage. The jaw becomes locked in consequence in an open position, resembling unilateral dislocation. As a rule the condition is comparatively easily corrected by movement of the jaw, assisted, sometimes, by the hand.

Cases are also described in which the mouth has been fixed for some time in an open position from spasm of the depressor muscles.

A few cases are reported of dislocation backwards with inability to open the mouth. The condition may be complicated by fracture into the external auditory canal.

Clavicle.

Dislocations of the clavicle may occur at the sternal or acromial end, the latter being much more frequent.

The **sternal end of the clavicle** may be dislocated forwards, upwards or backwards.

Sternal end of clavicle forwards. This dislocation is the most common; is generally due to blows upon the shoulder, but may also be caused by muscular action. The capsule is torn, as are also the anterior

and posterior sterno-clavicular ligaments, while the clavicle, carrying with it the clavicular insertion of the sterno-mastoid, is displaced forwards, and often a little downwards, where it lies on the front of the sternum, immediately under the skin. The interarticular cartilage may accompany the clavicle or remain attached to the sternum, and the rhomboid and interclavicular ligaments suffer in varying degree according to the amount of displacement.

Symptoms. The bone forms a marked prominence under the skin unless masked by swelling which generally supervenes, and the clavicular portion of the sterno-mastoid is prominent. The head may be inclined slightly to the affected side, and the shoulder is depressed. Arm movements are not free and are accompanied by pain at the affected joint.

Reduction may be attempted by bracing the shoulders backwards while the knee is pressed against the spine. Reduction is generally comparatively easy, but may be difficult to maintain, sometimes necessitating operation. After reduction keep shoulder forward by anterior figure of eight bandage, and apply pressure over clavicle by pad or spring truss (loop under axilla), support elbow in sling, and bandage arm to side.

Recurrent cases may be treated by injection of irritants.

Unreduced cases have generally good movement and power of the arm.

Dislocation of the sternal end of the clavicle upwards is very rare. It has been produced by blows on the shoulder, the sternal end of the clavicle tearing the capsule, and sometimes the rhomboid ligament and fibres of the subclavius muscle, and coming to rest on the top of the sternum, between the sterno-mastoid in front and the sterno-hyoid behind.

Reduction may be accomplished by drawing the shoulder outwards and pressing the clavicle into position. The arm may then be put up in Sayre's method for

fractured clavicle, and patient kept recumbent with narrow pillow between shoulders.

Dislocation of the sternal end of the clavicle backwards may be associated with displacement upwards, which is less common, or downwards. It is caused by severe direct or indirect violence. The clavicle lies behind the manubrium and the sterno-hyoid and thyroid muscles, and sometimes displaces or compresses the trachea and oesophagus, causing difficulty in breathing and swallowing. The structures at the root of the neck may also be compressed.

The absence of the clavicle may be masked by swelling; the shoulder is elevated; movements of the arm are impaired, and there is pain over the part, increased by movement of arm or head.

Reduction may be obtained by bracing and raising the shoulder. Reduction is generally easier than in displacement forwards. The shoulders should be kept braced by a figure of eight, the elbow supported in a sling, and the arm bandaged to the side. Position may also be maintained by keeping the patient in bed with a narrow pillow between the shoulders. Where reduction is not complete, and even *in unreduced cases*, good movement of the arm is generally obtained ultimately.

The **acromial end of the clavicle** may be dislocated upwards—which is the most common dislocation of the clavicle—and very rarely it is displaced downwards.

Dislocation upwards is generally produced by falls or blows on the shoulder. The capsular ligament is torn and the clavicle rises, and when the dislocation is complete rests on the margin of the acromion process, where it forms a marked subcutaneous prominence. The clavicular portion of the trapezius is prominent, and there is generally difficulty in raising the arm to a right angle. Local pain, generally severe, is usually temporary.

Reduction may generally be accomplished by bracing back the shoulders and pressing the clavicle into its

place. It may be retained in position by treating by Sayre's method for fracture, combined with pressure on the outer end of the clavicle by pad kept in position by a loop of plaster taken round the flexed elbow and the ends crossed on the shoulder. In some cases operation and fixing with wire or catgut gives a good result.

Good movement of the arm is often ultimately obtained even in *unreduced cases*, but sometimes there is inability to lift the arm above the level of the shoulder.

Dislocation of the acromial end of the clavicle downwards is extremely rare, and is generally due to severe direct violence, with laceration of acromio-clavicular, coraco-clavicular, and coraco-acromial ligaments. There is a marked depression at the seat of injury, with pain on movement of the arm. *Reduction* by drawing the shoulder out and backwards is said to be easy; and retention of position, with the scapula and arm fixed to the side by bandage, is also said to be satisfactory.

Dislocation of both ends of the clavicle occasionally occurs in severe injuries, the sternal end being displaced forward.

Vertebral Column.

Dislocations of the vertebral column, without accompanying fracture, are not common. The cervical region, and particularly the 5th vertebra, is most often affected, then the dorsal, and very rarely the lumber region. The vertebrae possess a limited power of movement about two axes—antero posterior and transverse. As the antero posterior axis is directed downwards and forwards in the cervical and upper dorsal regions, *movement about this axis*, with consequent lateral flexion or scoliosis of the column, is generally combined with a degree of rotation. When these two movements of lateral flexion and rotation exceed the normal maximum the inferior articular facet of the upper vertebra, on the side of the convexity, rises above the upper facet

of the lower vertebra and is displaced forwards by the rotation action—*dislocation by rotation.*

Where *movement takes place about the transverse axis,* and exceeds normal limits, the two inferior facets of the upper vertebra rise above those with which they articulate and are displaced forwards—*dislocation by flexion.*

Dislocations by flexion therefore are bilateral in one direction, generally forwards, while those by rotation may be either unilateral, or bilateral in opposite directions.

In association with the dislocation, the intervertebral disc is generally completely detached from one or other vertebra, together with fragments of bone; the ligaments are torn or detached with portions of bone; the veins of the bodies and of the meninges are torn, with consequent free haemorrhage, but the vertebral arteries generally escape; the nerve trunks are torn at the points of emergence, and the cord and its membranes may escape injury, or may be compressed or even lacerated or ruptured. The cord is least likely to be affected where there is a bilateral dislocation in opposite directions: in unilateral dislocation it is likely to escape, or at worst to be compressed, whereas in bilateral dislocation it is often injured, particularly when the displacement is forwards.

Haemorrhage into the grey matter of the cord—*haematomyelia*—may occur even without recognisable lesion of the bones or ligaments, and may spread through two or three segments of the cord, sometimes involving the white matter. It causes immediate, but generally transient, motor paralysis, except of the muscles whose nerve nuclei have been destroyed, and while tactile sensation is preserved, pain and heat and cold sensations are destroyed.

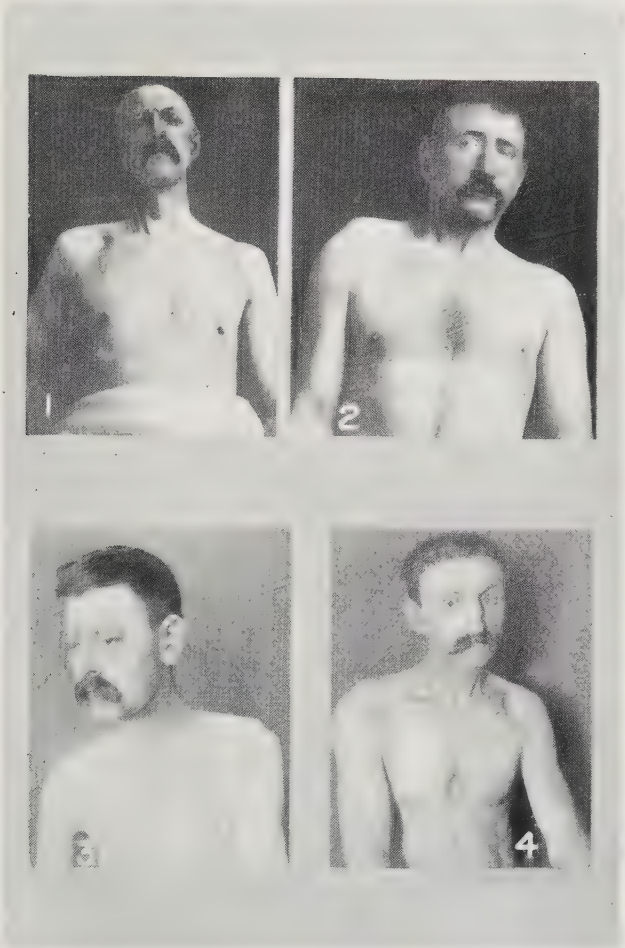
The *cause of dislocation* is generally forced flexion, but in the cervical region muscular action in producing extreme dorsi-flexion or rotation of the head may be the cause.

Symptoms. Deformity may be obvious, and is generally palpable. The spinous processes are palpable throughout, except in the upper cervical region; the transverse processes in the neck; and the bodies through the pharyngeal wall in the upper cervical and between sterno mastoid and trachea in the lower cervical. The displacement cannot be corrected by pressure, and there is often rigidity of the spine about the site of injury, although there may be abnormal mobility. Pain is generally present, either local only or also radiating, and is increased by pressure or movement. Paralysis may be absent, partial or complete, motor being more extensive than sensory, but there may be muscular twichings, neuralgic pain and hyperaesthesia. Sometimes there are vaso-motor and sympathetic phenomena when the lesion is in the cervical region, such as slow cardiac action or sudden rise of temperature. The pupils vary, are often fixed and may be unequal.

Attempts at *reduction* are by no means devoid of danger, but are best made as soon as possible after the accident. Traction under an anaesthetic, combined with careful flexion and rotation, and possibly gentle local pressure, may be tried. Reduction generally occurs with a distinct sound, and mobility is restored. Thereafter it is generally wise to apply a plaster casing for some weeks.

The *occiput* has rarely been displaced backwards on the atlas; *the atlas* has been displaced forwards, without rupture of the transverse ligament, on the axis, and also backwards, and bilaterally in opposite directions. In these conditions, with the exception of the last, death has been instantaneous as a rule, although some cases have survived for a considerable period.

Acute forward flexion of the head on to the chest may cause a diastasis or stretching of the atlas from the axis, with tearing of the ligaments, and generally forward displacement of the atlas. The odontoid process is



(1) Dislocation inner end left clavicle backwards.
(2) and (4) Dislocation outer end right clavicle (recent).
(3) Dislocation outer end left clavicle (old).

often broken, or the transverse ligament is torn. The chin is in contact with the chest, the spine of the axis forms a prominence behind, and the anterior arch of the atlas projects in the pharynx. Pain is generally severe. Where the patient survives, reduction may be attempted by traction upwards and slightly backwards.

Pure dislocations occur most often between the 4th and 5th or 5th and 6th *cervical*, and are most often uni or bilateral forward, or longitudinal stretchings (diastases).

In the *unilateral* form the head is generally turned toward the unaffected side; there is a painful swelling on the affected side of the spine, due to the transverse process and angulation, while the projecting body may be palpable through the pharyngeal wall. In the *bilateral* type the head may be bent forwards or backwards or backwards and to one side, and is generally fixed but may be freely moveable. Irregularity of the line of transverse processes in the neck and projection of the body in the pharynx or neck may be palpable. Paralysis, partial or complete, is often present.

Treatment in the unilateral form is by extension followed by rotation of the head toward the affected side, increasing the flexion toward the unaffected side and then rotating the head into its normal position. In bilateral forms traction is applied with local pressure above and below the displacement. A plaster casing should be applied for some weeks after reduction.

Dislocations of the *dorsal vertebrae* appear to be most frequently of the 12th. The displacement is generally bilateral forwards or backwards, paralysis being generally more marked in the former. The affected ribs have either been dislocated or fractured near the spine. Differential diagnosis from a fracture dislocation is difficult, but if reduction is performed with success and deformity does not recur, the probability of dislocation is considerable. Prognosis is more favourable in the lower dorsal region, but is uncertain.

Reduction is by extension and counter extension, and whether successful or not a plaster casing should be applied for some weeks.

A few cases of *dislocation in the lumbar region* have been reported. The arrangement of the articular processes, the size and elasticity of the intervertebral discs, and the support of the large muscular columns all tend to prevent the occurrence.

In addition to irregularity of contour and local pain and tenderness there may be paresis or incomplete paralysis, which is likely to be recovered from on reduction by means of extension and local pressure. Prognosis is more favourable than in the other forms, but some cases have proved immediately fatal.

Sternum.

Dislocations of the sternum are not common. Nearly all the cases reported occurred in males, the cause being direct, indirect, or rarely muscular violence. The *gladiolus* is most commonly displaced upwards and forwards upon the manubrium, but occasionally it has been displaced backwards, and longitudinal separation has also occurred. In the common form the second costal cartilage remains generally attached to the manubrium, while the second and third may be fractured. The condition is frequently complicated by severe injuries to other structures, such as fractures of the spine and ribs, and rupture of the thoracic viscera.

Symptoms. The upper end of the gladiolus presents a marked transverse projection, at either side of which a depression corresponding to the articulations of the second costal cartilages can be palpated. This point, together with the presence of the second costal cartilages below the level of the projection, serves to differentiate the condition from fracture. The neck and shoulders are bent forward, the upper ribs are depressed and the lower ones unduly prominent. Pain at

the seat of injury is sharp and increased by movement. Breathing is difficult, and causes pain.

Where the gravity of the other injuries does not contra-indicate, *reduction* may be performed by projecting the head and shoulders over the end of a table, and drawing them backwards. Firm plaster strapping should then be applied. Operative treatment in case of failure is not advisable unless there be signs of serious pressure on the thoracic viscera, and unreduced cases generally do well.

Dislocations have also been rarely caused by frequent pressure in certain trades, and from tubercle.

A few cases of *dislocation of the ensiform process*, generally with the apex directed backwards, and due to direct violence, have been recorded.

Local pain on pressure or on taking food, and vomiting, were prominent symptoms, and were relieved by hooking the process forwards.

Ribs and Costal Cartilages.

Dislocation of the ribs and costal cartilages are rare. A few cases are recorded of dislocation of the head of one or more *ribs*, generally as the result of great violence, and sometimes associated with fracture of the vertebrae.

The *costal cartilages* have been dislocated in a few cases, singly or in groups, generally as the result of crushing, the displacement being either backwards or forwards. The same may be said of dislocations of the costal cartilages from the sternum, which, however, have been caused by severe muscular action in some cases. Dislocation of one costal cartilage from another is reported to have occurred.

Shoulder.

Dislocations of the shoulder are more frequent than those of all the other joints taken together. This frequency is due to the small and shallow cavity of the

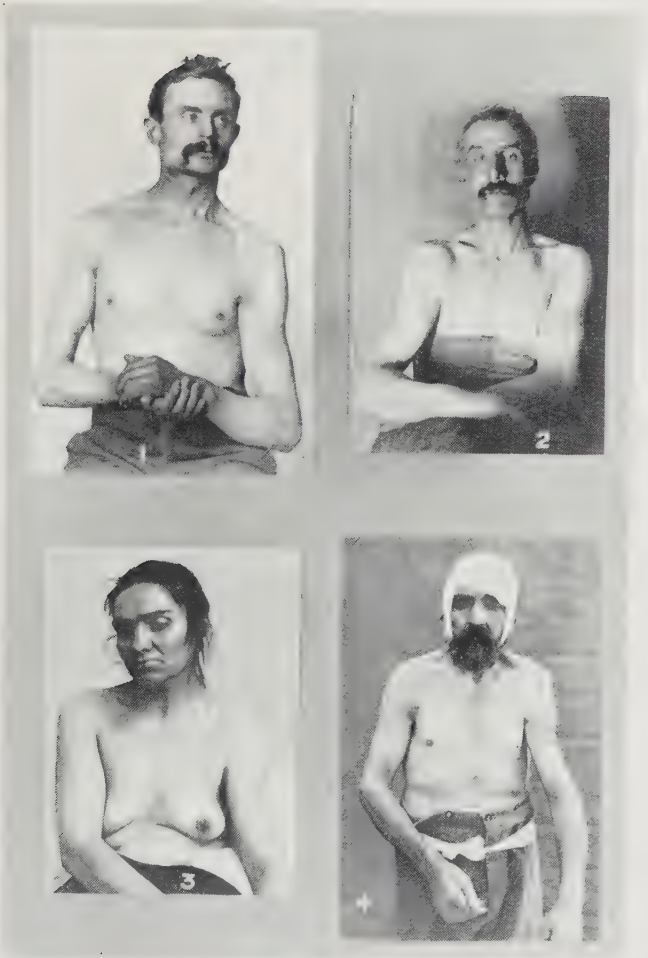
glenoid; the extent, thinness and comparative laxity of the capsule; the long lever action of the humerus; the large range of movement permitted, and the exposed position.

Above and posteriorly the joint is strengthened by the supra- and infra-spinati and teres minor muscles, while the subscapularis covers its inner aspect. The weakest part is below and in front, between the tendons of the subscapularis and teres major, and dislocations occur most readily at this part, indeed many hold that the majority of dislocations of the shoulder are first subglenoid. The *cause* is more often indirect than direct violence, transmitted from the hand or elbow while the limb is abducted and rotated outwards. The head of the humerus descends over the glenoid, while the long head of the triceps, lower part of the subscapularis and lower and inner part of the capsule are rendered tense. This movement continues until the humerus comes in contact with the acromion, and the great tuberosity with the upper margin of the glenoid, after which the upward movement of the arm is permitted by rotation of the scapula. If from any cause, as in sudden jerking of the arm, the scapula does not move, then the head is forced through the capsule at its weak inferior aspect.

Dislocation is most frequent during middle life, and most often occurs in males, but as age advances there is a proportionate increase in females.

Much the most common form of dislocation of the shoulder is the subcoracoid. An exaggeration of this type, known as subclavicular or intracoracoid, also occurs. Subglenoid dislocation is much less common, and subacromial or subspinous is uncommon.

Certain *symptoms* are common to all the varieties. Pain over the joint is generally intense for some time after the accident, and may cause shock and faintness. Pain and numbness may be caused in the arm from pressure of the head on the large nerve trunks. Marked



(1) Dislocation of shoulder: subcoracoid.
(2) ,, ,, ,, but tending toward intracoracoid.
(3) ,, ,, intracoracoid.
(4) ,, ,, subglenoid.

swelling over the joint generally occurs after a time. The patient generally inclines his head and body toward the affected side, and endeavours to support the affected limb, which is held in characteristic attitudes, with his sound hand. The acromion process is prominent, and the prominence is accentuated by the hollow beneath it caused by absence of the head. A straight-edge placed along the humerus rests upon the prominent acromion at one end and on the external condyle at the other, whereas, when the head is in position, its prominence, together with the belly of the deltoid, keeps the straight-edge about a finger breadth from the acromion when it is touching the external condyle. The patient is generally unable to touch the crest of the ilium with the elbow, or, if he succeeds in so doing, to place his hand at the same time upon the sound shoulder. The vertical circumference of the shoulder is considerably increased, but swelling may account for a proportion of this, and must be discounted.

Subcoracoid dislocation may be due to direct violence, such as a blow on the upper and outer part of the shoulder, or to muscular action, but is generally due to indirect violence, such as a fall on the abducted arm or the wrench caused by catching hold of a support while in the act of falling.

The capsule is torn at its lower and inner part, the rent extending in some cases over two-thirds of the periphery. Rarely the capsule remains intact, the periosteum to which it is attached being torn from the scapula. The head, under the action of the dislocating force, or of the muscles, particularly the pectoralis major, passes inwards, and comes to rest beneath the coracoid process, under the short head of the biceps and coraco-brachialis, the anatomical neck resting on the anterior edge of the glenoid.

The posterior surface of the head sometimes strikes the anterior margin of the glenoid so violently as to be indented by it, or the margin of the glenoid may be fractured.

The subscapularis muscle may be pushed aside, but is generally ruptured, while occasionally it is detached from its insertion into the humerus, and rarely the lesser tuberosity has been detached. The supra and infra spinati and teres minor muscles may be stretched or torn from their attachments, or the great tuberosity may be detached, permitting the long tendon of the biceps to slip out of its position and thereby hinder reduction, by interposing between the head and its socket.

The axillary vessels and nerves are pressed inwards and are sometimes injured, and the circumflex nerve is frequently damaged.

Symptoms. The *position of the arm* is characteristic in each of the dislocations of the shoulder. In the subcoracoid variety the forearm is flexed, and the patient supports it with the sound hand. The upper arm is slightly abducted from the side, and, in addition is generally directed slightly backwards, although this is not constant. The prominence of the acromion, and the flattening beneath it, is marked unless concealed by swelling, and the deltoid appears to be inserted into the humerus at an angle. The anterior fold of the axilla is depressed. There is a fulness of the outer part of the subclavicular fossa, and the head can be palpated in its abnormal position under the coracoid. It may also be felt by abducting the arm and palpating from the axilla. If, during palpation the arm is rotated by means of the flexed forearm, the head can be felt to move with it. On the other hand the head is wanting from the glenoid cavity and the fingers can be pressed in deeply under the acromion. The length of the humerus measured from acromion to external condyle is generally slightly greater than that of the normal side while the arm is hanging down, but when the arm is fully abducted it is less.

If the capsule be freely lacerated the patient may be able to touch the side with the elbow and at the same time the sound shoulder with the affected hand, but

otherwise there is generally inability to perform this test.

An *incomplete dislocation* of the shoulder, probably without rupture but only stretching of the capsule, may occur. In these cases the deformity may be slight, but the pain is very severe, and the patient is unable to move the arm. Reduction may be easy, and occur during examination or from lateral pressure on the shoulder.

Subclavicular or Intracoracoid dislocation may be regarded as an exaggeration of the subcoracoid, in which the head lies to the inner side of the coracoid process, due to further action of the dislocating force, whether violence or muscular action. The capsule is extensively torn, the great tuberosity generally detached, the tendon of the biceps displaced outwards or torn, the subscapularis ruptured extensively, and the head, generally passing behind the muscles attached to the coracoid process, comes to lie upon the serratus magnus covering the chest wall on one side, and is in contact with the costal margin of the neck of the scapula on the other. The large vessels and nerves lie generally behind the head.

The *symptoms* are similar to those of the subcoracoid variety but differ in degree. The arm lies close to the side and the elbow may even touch it. The shoulder is much flattened, and there is a fulness below the clavicle to the inner side of the coracoid. Abduction may only be possible by movement of the scapula. Rarely the arm may be fixed in complete horizontal abduction.

This type may generally be converted into an ordinary subcoracoid by extension downwards and outwards.

Reduction of a subcoracoid dislocation is often easy, particularly if attempted soon after the accident, while the patient is still feeling faint, and the muscles are relaxed. In such cases a simple unexpected movement, such as bringing the arm across the back of the chair while the patient is in the act of sitting down, may be effective. But in some cases there is an impediment to

reduction, such as opposition of an intact portion of the capsule in front, obliteration of the rent, interposition of capsule or tendons, or muscular contraction. Muscular contraction generally becomes marked some time after the accident, and particularly after unsuccessful attempts have been made to reduce the dislocation, and while reduction is often easy at first it is often very difficult after several days have elapsed and various unsuccessful attempts have been made, even where there is no mechanical obstruction. In attempting reduction Kocher's method is often tried first.

Kocher's method aims at making the rent in the capsule gape by pulling upon the stretched and twisted anterior portion of the capsule by means of external rotation: relaxing the upper part of the capsule by raising the elbow and carrying it forward, the head being drawn back into position by the manipulation aided by the tension of the lower portion of the capsule, after which rotation inwards returns the head to the socket. The method is carried out in three steps, the patient being seated with his back to the wall.

(1) Flex the elbow to a right angle, and with one hand press it firmly into the side and maintain it there: using the forearm as a lever, and holding it with the other hand just above the wrist, rotate the arm outwards to its full extent. This movement is often resisted and causes pain, but the resistance must be overcome by steady pressure.

(2) While maintaining the flexion and external rotation the elbow is pushed forwards and slightly inwards until the arm is horizontal.

(3) Rotate the arm inwards, bringing the hand to the sound shoulder.

If the process is succeeding, a fulness should appear in the deltoid region during the first movement, and this should become more pronounced during the second movement.

If Kocher's method fails trial may be made of traction

downwards and outwards, combined with direct pressure on the head; or the patient may be laid on a mattress and the operator placing his foot on the acromion slowly and steadily extends the arm till it is raised above the head. If the head does not slip in, it may be pressed in from the axilla.

In difficult cases of some days standing occurring in big muscular workmen the writer has found the following method almost invariably successful. The patient lies on a mattress and the operator standing on a low stool at his side, catches the affected arm with both hands just above the wrist, and slowly and steadily raises the patient by pulling on the arm. At first the arm is felt to be held stiffly, but after a minute or so, during which the steady pull must be maintained, the muscles relax and the arm becomes straight and flaccid. Once relaxation is complete an attempt may be made by rotating slightly outwards and giving the arm a shake to reduce the dislocation, but, if this fails, once relaxation is again complete, the operator jumps from the stool, across the patient, to the floor, bringing the arm across the patient's chest with a quick movement. This generally succeeds at the first attempt. Practically the same method reversed is to place patient in a hammock with a hole in it through which the affected arm hangs down toward ground. A weight of ten pounds is attached to wrist and reduction frequently occurs spontaneously and painlessly after a few minutes.

Where these methods do not succeed, it will generally be wise to give an anaesthetic such as ethyl chloride and ether, and again attempt reduction by manipulation. Undue force should not be employed as fracture of the humerus and serious damage to the vessels may result.

Where moderate force does not succeed, and in old standing cases, it is safer to operate.

After reduction the arm should be gently massaged, supported in a sling and bandaged to the chest wall. Daily massage should be applied from the outset, and

gentle passive movement commenced on the second or third day, abduction and external rotation being avoided.

Where *operation* is decided on, an incision along the anterior border of the deltoid may be employed, with, if necessary, an additional outward incision at the upper end, with partial detachment of the deltoid from its acromial attachment. The deltoid and pectorals are separated: the coraco-brachialis and short head of biceps drawn in and pectoralis minor up. The subscapularis tendon is now exposed by external rotation of the shoulder, and divided, after which reduction is generally easy by rotation of the arm inwards, and the subscapularis is then stitched and the wound closed (Dollinger).

If there still be difficulty, or if the dislocation be complicated by fracture, or the dislocation be old standing, excision may be performed.

The great majority of uncomplicated early subcoracoid dislocations of the shoulder can be reduced, and recovery is generally complete. Restoration of function may however be delayed or prevented by fibrous anchylosis at the joint or paralysis of the muscles, particularly the deltoid. In many cases these conditions improve under treatment.

Where the *dislocation remains unreduced* movement is generally much impaired, although in some cases increased mobility of the scapula forms a compensating element, so that the hand may even be raised to the head.

Subglenoid dislocation is produced by forcible elevation of the arm as from a fall on the extended elbow. The capsule is torn on its inferior aspect between the triceps and subscapularis, the rent being generally small, and the head, descending, rests against the flattened upper portion of the axillary border of the scapula on the inner side of the triceps under the lower and inner edge of the glenoid cavity. Less frequently it may be displaced directly downwards on to the long head of the triceps.

Symptoms. The elbow is markedly abducted from the side, so that the patient has to bring his sound hand over to the affected side in order to support the forearm. The acromial prominence and the flattening beneath it are pronounced, and the angle at the insertion of the deltoid is very marked, indeed this point is the one likely to first attract the attention of the student. The head can be easily palpated in the axilla and diagnosis is generally easy.

Rarely the upper arm may be fixed at right angles to the trunk, the patient resting his hand on his head (Luxatio erecta).

Reduction may first be attempted by direct reposition. Standing by the patient's side, the operator places his fingers in both sides of the axilla, and his thumbs on the acromion, and endeavours to lift the head into position. If this fails he may apply traction, slightly increasing the abduction as he does so. The fist is then placed in the axilla and pressed upwards and outwards, and the arm is adducted. Traction upwards and outwards above the head is generally successful but rather more dangerous on account of possible overstretching of the vessels around the head of the bone.

Dislocation of the shoulder backwards. This dislocation may be either *subacromial* or *subspinous* according to degree, but both forms are frequently referred to as subspinous. The cause may be direct violence, as a blow on the front of the shoulder, or muscular action, but is probably most frequently a fall or blow on the arm when adducted and inverted. The capsule may be perforated by the head or extensively torn from its insertions; the muscles may be stretched or torn, and the head lies generally beneath the acromion or rarely the spine, or between the infraspinatus and teres minor muscles.

Symptoms. The position of the arm is again generally characteristic. The arm hangs by the side, the elbow advanced in front of the body, and the arm is

rotated inwards so that the olecranon presents anteriorly, while the palm of the hand is turned outwards, the thumb being directed backwards. The shoulder is flattened in front but full behind, and the coracoid may be prominent. In old standing cases the deformity is easily recognised, but in recent cases diagnosis may be difficult. Voluntary movement is destroyed for a time and in unreduced cases or may be entirely restored, as in case figured (or may remain very defective).

Treatment by traction under anaesthetic, combined with pressure on the head from behind forwards and counter pressure on the acromion, is generally successful and easy, but in some cases there is a tendency to recurrence.

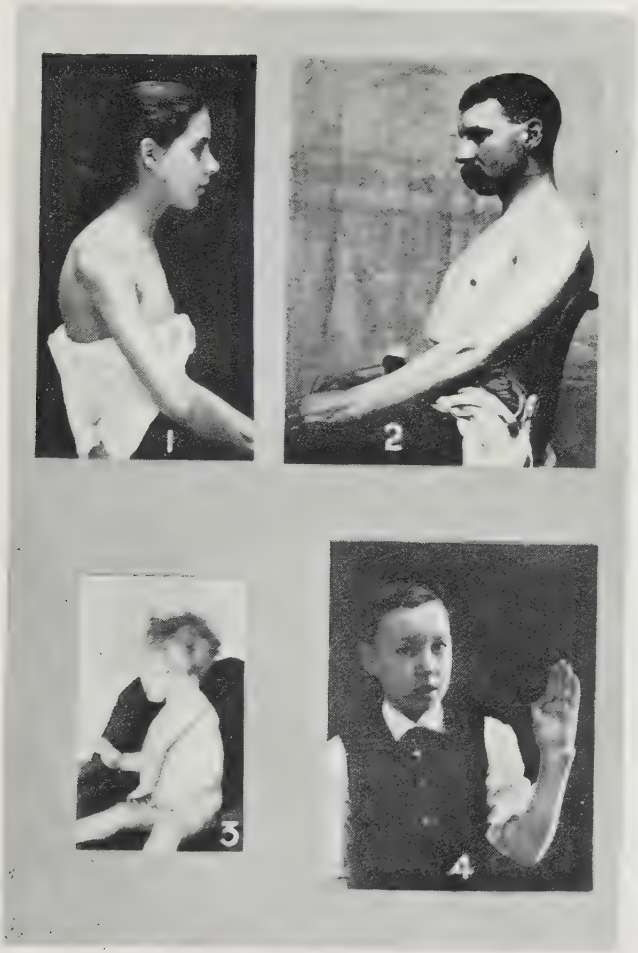
Supra-glenoid and *supra-coracoid* dislocations have very rarely occurred.

Congenital dislocations may be due to maldevelopment of the joint, dislocation before or at birth, or to paralysis before or at birth.

In the case of the shoulder the third of these is much the most common cause, and it is well to remember that a condition closely akin to *Erb's paralysis*, and affecting the same muscles—deltoid, biceps, coraco brachialis, spinati and supinators—may be caused by traction on the cords of the brachial plexus from pulling on the head of the child during delivery or exerting great pressure on the supraclavicular fossa. The *position of the arm* in these cases closely resembles that found in subspinous dislocation, and as subspinous dislocation is the form generally found congenitally, the differential diagnosis may be difficult when the head is still small and composed of cartilage.

The *diagnosis* is further complicated by the fact that such a paralysis is generally the forerunner of a so-called congenital subspinous dislocation.

In the *purely paralytic condition* the arm is markedly rotated inwards, and the ulnar border of the hand presents anteriorly. Flexion at the elbow is consequently



(1) and (2) Dislocation of shoulder: Subspinous (old).
(3) Congenital (paralytic) subspinous dislocation of shoulder.
(4) Dislocation of ulna forwards at radio ulnar joint.

much impeded, and attention is apt to be directed to the elbow, and the condition of the shoulder overlooked. It is stated that the condition often improves rapidly, but the writer has known cases where it did not improve with regular massage and electrical treatment.

Occasionally the paralysis may be due to the dislocation. In some cases of dislocation the diagnosis is easy, the head forming a palpable and sometimes even a visible swelling under the scapular spine, while the atrophy of the muscles may be marked. The position of the arm is generally that of rotation inwards, with the elbow slightly flexed and advanced in front of the body while the ulnar side of the hand is directed forwards, and the palm is turned outwards.

Treatment. In the earlier cases it will probably be well to treat the paralysis first, and if it does not yield rapidly to massage and electricity, operation should be performed on the brachial trunks. The head of the bone may be replaced at the same time, or subsequently manipulated into position.

In old standing cases attempts may be made to replace the head after section of the subscapularis tendon as already described.

Pathological dislocation of the shoulder is not common.

Elbow.

Dislocation of both bones backwards is much the most common dislocation at the elbow, and occurs with comparative frequency in children. It is generally produced by a fall on the palm of the outstretched hand, the elbow being extended, but may also be caused by a wrenching inwards of the flexed forearm or by direct violence. It is supposed that hyperextension first occurs combined in many cases with a degree of abduction of the forearm, causing rupture of the internal lateral ligament, and then of the anterior ligament, and the olecranon coming in contact with the humerus acts as a fulcrum, levering the coronoid away from the

humerus, after which the lower end of the humerus passes down in front of the bones of the forearm.

The internal lateral ligament is always torn or detached; the external lateral ligament is generally likewise affected, but may be partially preserved and materially affect the position of the limb and cause difficulty in reduction; and the anterior ligament is torn, while the orbicular ligament is generally unaffected. The capsule behind the external condyle may be detached along with the periosteum, and cap the backward displaced head of the radius.

The displacement of the bones may be *incomplete*, the coronoid resting on the trochlea; or *complete*, the coronoid lying opposite the olecranon fossa of the humerus, and the head of the radius behind the external condyle. Where there is marked abduction rather than hyperextension of the forearm at the moment of dislocation, the humerus is driven down and inwards after the internal lateral ligament has been ruptured, so that the head of the radius lies outside the capitellum, under the external epicondyle, while the coronoid rests on the posterior surface of the external condyle, constituting a **backward and outward** dislocation.

The internal epicondyle may be detached and displaced upwards and backwards, the internal lateral ligament remaining attached to it; the coronoid process is not infrequently fractured, and even the olecranon or head of the radius may be damaged. The tendon of the brachialis anticus is stretched or torn; the median and perhaps the ulnar nerves may be similarily affected and the brachial artery may be damaged. The dislocation may be rendered compound by projection of the trochlea through the skin at the front of the elbow.

Symptoms. The forearm is generally slightly flexed, but may be extended or even hyperextended; it may be in any position between pro and supination, as rotation movement is voluntary, and it may be straight, adducted, or abducted. Slight flexion and extension

are possible but painful, and there is abnormal lateral mobility. The forearm is shortened about an inch as measured from the external condyle of the humerus to the radial styloid. When viewed from the front the shortening appears to be in the forearm, whereas, when viewed from behind it appears to be in the upper arm owing to the displacement upwards of the olecranon. The olecranon forms a marked projection behind, increased on flexion, and the tendon of the triceps being carried with it away from the humerus, forms a curving ridge with a depression on either side, in the outer of which may be seen a slight projection marking the position of the head of the radius.

In the normal arm and in transverse supracondyloid fracture of the humerus, the tip of the olecranon, when the forearm is flexed, lies well below a line joining the epicondyles, whereas in dislocation it lies above it. The rounded head of the radius with its central depression can be palpated behind the external condyle, and may be felt to rotate on pro and supination.

In front there is a marked fulness due to the lower end of the humerus with the overlying muscles, and the trochlea can generally be palpated.

Diagnosis by the above signs is generally easy, but swelling comes on rapidly and may mask the appearances and even render palpation of the bony points difficult. In such cases an X-ray photograph may be necessary to confirm the diagnosis.

Damage to the bones and stripping of periosteum, particularly in children, is apt to be followed by new bone formation, which occurs most frequently in front of the humerus, under the brachialis anticus, giving rise to marked limitation of movement and difficulty of diagnosis, especially in unreduced cases.

The *prognosis* is good and reduction is generally comparatively easy if accomplished soon after the accident, but after six weeks reduction is difficult, and function generally limited even if reduction be accomplished. On

account of the possibility of new bone formation, however, it is generally wise to give a guarded prognosis.

Reduction is accomplished with minimal damage to the parts if an attempt is made to return the bones to their positions by following the route by which they emerged. With this object in view, the limb is first slightly hyperextended, an anaesthetic being used if necessary, so as to free the coronoid from behind the trochlea, and then traction is employed, and the lower end of the humerus pressed backwards, generally by the operator's knee. Lastly, while traction is still maintained, the joint is slowly flexed, and the bones return to position, often with a snap.

Reduction is often performed successfully by seating the patient, the operator resting his foot on the edge of the chair and placing his knee in the bend of the elbow, while he grasps the wrist and bends the arm. The knee is now pressed against the upper ends of the radius and ulna, so as to free the coronoid and, while so doing the forearm is pulled upon and slowly but forcibly flexed. This method is apt to cause more damage than the former.

Recurrence is unlikely unless the coronoid has been fractured. The forearm is flexed and supported with a sling and massage and passive movement are begun at once. Even where the *coronoid is fractured* the same treatment may be adopted, as displacement of the fragment is generally slight, but a posterior gutter splint may be used as a precaution, and passive movement must be used with caution for the first ten days.

Where the dislocation has existed for some time, it is generally necessary to free the parts by extension, flexion, and lateral movements before attempting reduction. As such movements tend to further laceration, and hence increase the tendency to new bone formation, some advocate reduction by open operation. Where the dislocation has been present for more than five or six weeks, an excision, partial or complete, generally gives the best result. Complication by fracture of the olecranon or

(1) Dislocation of both bones of forearm backwards.
(2) Dislocation of both bones of forearm backwards and outwards.
(3) Dislocation of head of radius forwards (old).
(4) Dislocation of both bones outwards (complete). (The prominence some distance above discoloration at elbow is the olecranon).

head of the radius is generally best treated by operation.

Where the *dislocation is both backwards and outwards* an attempt may first be made, under an anaesthetic, to render the dislocation an entirely outward one—thereby following the probable route taken by the dislocation—and then reduce; or, if this fails, it may first be converted into a purely backward dislocation, and then reduced as above. The latter method is perhaps more often employed.

Where the *dislocation is compound*, even if the parts be severely lacerated, every endeavour should be made to avoid amputation, by following the rules laid down in the section on compound fractures. Even if the joint be disorganised the patient may, in many cases, retain entire or partial use of his hand and fingers, and a subsequent excision may restore the use of the elbow.

Lateral dislocations of the elbow, without a degree of backward displacement, are rare, and are generally due to falls on the outstretched hand, adduction of the forearm at the time of the accident tending to produce outward displacement, and abduction inward displacement. They may also be produced by blows on the elbow. Dislocation inwards is always incomplete, while outward dislocation may be incomplete or complete.

Dislocation of both bones inwards is said to be rather more frequent than outward displacement. The lateral and anterior ligaments are torn, the sigmoid cavity of the olecranon embraces the internal condyle, and the head of the radius lies below and behind the inner part of the trochlea. The forearm is slightly flexed and pronated, and flexion and extension are free and painless within limits. The external condyle forms a marked prominence, but the inner is masked by the swelling due to the olecranon, while the triceps forms a slight ridge running down and inwards. *Reduction* is by extension, combined with lateral pressure upon the ulna outwards.

In *incomplete outward dislocation* the sigmoid notch rests against the external condyle while the head of the

radius projects beyond it. The internal condyle is frequently torn off, particularly in children, and may lodge in the trochlear groove rendering reduction difficult, and sometimes impossible. The internal lateral ligament is always torn, and generally the inner portions of the anterior and posterior ligaments. The forearm is flexed and pronated, and flexion and extension are limited and painful. The internal condyle is prominent and the skin stretched tightly over it. The head of the radius projects on the under surface of the condyle, the olecranon is abnormally prominent, lying behind the external condyle, and the triceps forms a ridge running down and outwards.

Reduction may be accomplished by first hyperextending, thereby pressing the tip of the olecranon against the back of the humerus so that it acts as a lever and lifts the sigmoid over the trochlear ridge. While this is being done, inward lateral pressure should be applied to the head of the radius. Where the *internal condyle is separated* and prevents reduction, an attempt may be made to convert the dislocation into a posterior one first, which may have the effect of removing the obstacle. If this does not succeed, operation may be performed, and the fragment removed through an incision on the inner side.

Complete external dislocation of both bones is rare. The forearm is pronated and flexed, the sigmoid cavity embraces the outer surface of the external condyle, and the head of the radius lies above the ulna, in front of the humerus. The lateral and other ligaments are torn, and the ulnar and radial nerves may be damaged.

Reduction is generally easy by means of extension and direct manipulation, owing to the very considerable laceration of the ligaments and muscles.

Dislocations of both bones forwards are very rare, and have been caused by severe blows on the back of the elbow, and by falls on the palm of the hand. They are often associated with great laceration of the soft

parts and fracture of the bones, particularly the olecranon, and when due to direct violence are often compound. Uncomplicated cases are described as *incomplete* when the tip of the olecranon rests on the under surface of the trochlea and as *complete* when it lies in front of the trochlea. The former is the more common. The limb is generally slightly flexed and lengthened. The back of the elbow is flattened, the olecranon fossa is empty, and a transverse depression may be felt between the lower end of the humerus and the olecranon. In the incomplete form the olecranon forms a prominence below the humerus on flexion, and the forearm is lengthened on extension. In the complete form the forearm is shortened on extension but lengthened when flexed to about a right angle. In the complete form the triceps is probably ruptured. The incomplete form is generally easily *reduced* by flexing the elbow over the knee and pushing backwards. The complete form might be reduced by flexing beyond a right angle, depressing the bones close up to the elbow, and then pressing backwards. In cases complicated by fracture, operation generally gives the best results.

A few cases have been recorded of *divergent dislocations* of the bones of the forearm. In the majority the ulna has passed up behind the humerus, and the radius in front (antero-posterior type), but a transverse type in which the olecranon passes to the inner and the radius to the outer side of the humeral condyles has been reported. The cause is generally severe direct or indirect violence, the ligaments are all torn, and the muscles stretched, contused, and lacerated, and the coronoid frequently fractured.

Treatment for the antero-posterior type is by traction on the forearm so as to bring the ulna into position, after which with the forearm pronated and adducted, an attempt may be made to push the radius inwards into position, but the orbicular ligament may resist the attempt and an operation be necessary.

Dislocations of the ulna alone are generally backward, but dislocations inwards and forwards have also occurred. The *backward* displacement is generally due to a fall on the outstretched hand, and varies in degree, the coronoid resting behind the trochlea, or being lodged in the olecranon fossa or the olecranon resting behind the radius. The first of these forms is the most common. The arm is generally almost straight, and flexion is painful whereas pronation and supination are free. Deflection of the forearm to the ulnar side may be noted when extended. The olecranon forms a prominence behind, and is above the level of a line joining the condyles. The head of the radius may be felt in position.

Treatment is by grasping the forearm and particularly the ulna, and supinating, abducting, and hyperextending.

Dislocations of the radius alone are more common than those of the ulna alone, and may occur in several directions—backwards, outwards, forwards, and by elongation.

Dislocation backwards is generally complete and due to a fall on the hand or elbow. The ligaments on the outer side of the elbow, including the orbicular, are torn, and the head of the radius lies behind its normal position in extension and behind and below it in flexion.

The elbow is slightly flexed, the forearm pronated, movements are limited and painful, and the cupshaped head of the bone can be palpated posteriorly.

Reduction may generally be accomplished by traction on the wrist with the forearm extended and supinated, and pressure on the head of the radius. If a portion of capsule intervenes and hinders reduction, operation may be necessary,

Uncomplicated *dislocation outwards* is rare. The forearm is slightly flexed and pronated, and movements limited. The head may be felt lying to the outer side of the condyle. *Reduction* is by adduction of the forearm and pressure upon the head. If the orbicular ligament prevents reduction operation may be necessary.

The *most common dislocation of the radius alone is the forward one.* It may be produced by direct violence, or by traction combined with over-pronation. The capsule is torn anteriorly, and the head of the radius projects through the rent, while the untorn orbicular ligament encircles the neck of the radius. The head rests, in partial flexion of the limb, on the anterior surface of the external condyle, in contact with the coronoid process of the ulna, or separated from it by the tendon of the brachialis anticus.

Symptoms. The elbow is somewhat flexed, and generally pronated and sometimes abducted. Movements are painful, but involuntary movement is generally fairly free in all directions, except supination, and flexion which is arrested at about right angles by impact of the head of the radius on the front of the humerus. The head of the bone can generally be palpated and may form a prominent swelling at the fold of the elbow.

Treatment is by traction and adduction upon the extended and supinated forearm, while pressure is made on the head of the radius. The displacement is apt to recur, due, probably, either to interposition of a portion of capsule or to bodily displacement of the radius upwards. A position of flexion is most likely to prevent recurrence.

Dislocation by elongation is a form which occurs in young children between the ages generally of one and three, and rarely after six. The cause is generally traction, possibly with adduction, of the extended forearm, particularly when applied with a jerk. The child cries with pain, and will not use the limb, which hangs at the side or is supported by the other hand as it crosses the abdomen, the forearm being pronated.

There is tenderness over the head of the radius which is displaced slightly forwards, leaving a narrow space between it and the capitellum. There is also tenderness in some cases at the back of the wrist, and swelling may occur in both positions after a day or so. Passive move-

ment is permitted in any direction except supination.

The front portion of the head has emerged beneath the orbicular ligament.

Reduction is generally easy by supination, combined if necessary with flexion, but recurrence must be guarded against.

Dislocation of the radius is sometimes *complicated* by fracture of the ulna, and this should be particularly suspected if the swelling be considerable and extends above the elbow. Reduction is said generally to be easy by traction on the extended elbow, direct pressure on the radius, and then flexion of the elbow. Retain after reduction flexed within a right angle, midway between pro and supination.

Old standing dislocations may generally be treated with considerable success by excision, partial or complete.

Wrist.

Dislocations at the wrist may involve the radio-ulnar joint or the radio-carpal joint; dislocations of the carpal bones or of the carpo-metacarpal joints.

The **Radio-Ulnar joint.** The ulna may occasionally be displaced backwards or forwards.

Dislocation backwards is generally produced by over-pronation, the posterior radio-ulnar ligament is probably torn, and the lower end of the ulna forms a marked projection on the back of the wrist, while there is a corresponding depression in front. The hand is pronated and sometimes adducted. Supination is difficult but flexion and extension are free.

Reduction is by direct pressure on the ulna combined with supination or abduction of the hand.

Dislocation forwards is generally due to direct violence. The lower end of the ulna forms a prominence in front and there is a corresponding depression behind.

Reduction is by direct pressure on the ulna. In both forms a fracture of the lower end of the radius may co-exist.

Dislocations of the **radio-carpal joint** are not very common, but it is difficult to estimate their frequency as, on the one hand, a Colles' fracture closely resembles and may be mistaken for a dislocation backwards, while, on the other, dislocations are often extremely easily reduced.

The dislocation may be backwards or forwards; very rarely outwards.

Dislocation backwards is generally due to great violence, such as a fall on the hand from a height, or a fall on the knuckles, the fingers and wrist being flexed. The ligaments, particularly the anterior and external, are extensively lacerated, while fracture and avulsion of the posterior ridge of the lower end of the radius may take the place of laceration of the posterior ligament. (Barton's fracture.) The radius projects forwards, displacing or rupturing the flexor tendons, and sometimes perforating the skin, but the radial artery and median nerve generally escape. The extensor tendons are displaced but not torn. The carpus may be displaced entirely on to the back of the radius, or it may only so rest on the radial side, the ulnar side remaining in situ, or the bones of the carpus may be separated from one another.

The condition closely resembles a Colles' fracture, but the swelling posteriorly does not extend far beyond the styloid processes, as it does in fracture, and the styloid processes retain their normal relationship to one another, the radial styloid being the lower, whereas in fracture the radial styloid is displaced upwards. The hand and wrist may be somewhat flexed, and are generally deflected toward the ulnar side, instead of toward the radial side as in fracture. The swelling in front extends further down in dislocation, and may reach the ball of the thumb, while it also ends more abruptly than in fracture.

Treatment is by traction on the hand and direct pressure —in some cases a slight inadvertent touch has been sufficient to effect reduction, and recurrence is not common.

Dislocation forwards may be due to forcible hyperflexion or extension of the wrist, or to direct violence. The ligaments are extensively ruptured, and the carpus is displaced on to the anterior surface of radius and ulna. The wrist and fingers are generally slightly flexed, and movements are restricted and painful. The lower ends of radius and ulna form a marked projection on the back of the wrist, while beyond them there is a marked depression. In front the carpus forms a marked rounded projection. The hand is shortened as shown by measurement from the styloid processes to the heads of the metacarpals.

Reduction is easy, by traction, aided if necessary by direct pressure.

A *spontaneous dislocation* forwards has been described, occurring in young persons who use the hands constantly as in washing clothes or playing the piano. The end of the ulna projects markedly on the dorsal surface of the wrist while the lower epiphysis of the radius is bent forwards, and the carpus carrying with it the hand is displaced slightly forwards toward the palmar aspect. Dorsal flexion is generally limited while palmar flexion may be increased. There may be considerable pain, particularly over the projecting lower end of the ulna.

Generally no treatment is necessary beyond attending to the regular use of all the muscles, as the condition tends to improve after growth ceases.

Dislocations forwards and backwards at the mid-carpal joint have been reported but are extremely rare.

A *mid-carpal fracture dislocation* occurs occasionally in adult males, generally as the result of a fall on the palm of the hand. The scaphoid is fractured, and the proximal fragment, together with the semilunar, is displaced forward. The other bones, and particularly the os magnum, may be displaced. The hand is slightly displaced toward the radial side; the end of the ulna is prominent; the displaced bones form a palpable projection under the flexor tendons, and the fingers are flexed.

The wrist is shortened, and a gap may be palpated beyond the dorsal extremity of the radius. Reduction by traction and dorsal flexion with pressure on the fragments may be tried, and if not fully successful, early excision of the fragment of scaphoid and the semilunar through incision along border of palmaris longus tendon should be performed.

Dislocations of the individual bones of the carpus are also rare, those of the semilunar and os magnum being most common. The cause appears to be forced flexion as a rule.

The *semilunar* may be displaced forwards by forcible dorsiflexion, and form a distinct prominence beneath the flexor tendons, while sometimes the dislocation is compound. Symptoms of pressure on the ulnar nerve may be present. Treatment is by excision if necessary.

Dislocation of the *os magnum* produces a rounded swelling above the base of the metacarpal.

Sometimes the head of the os magnum is dislocated from the scaphoid and semilunar bones and projects on the dorsum of the wrist on dorsiflexion as a small rounded swelling. Flexion and extension are limited, and symptoms of pressure on the median nerve may be present. It has been described as a partial dislocation of the bone occurring chiefly in those who make constant use of the hands. Treat by fixing wrist in dorsiflexion for ten days : if this does not succeed, excise.

Hand and Fingers.

Dislocation of each of the **individual metacarpal bones** except the fifth has been reported.

The *metacarpal of the thumb* has very rarely been dislocated forwards; it is occasionally dislocated completely backwards and frequently incompletely backwards. The cause may be forced flexion or extension or direct violence. In the *incomplete* form the base of the metacarpal bone forms a swelling between the

tendons of the extensor primi and secundi internodii, and the thumb is flexed at the carpo metacarpal joint. In the *complete* form the prominence of the lower end of the metacarpal bone is more distinct, and the thumb is shortened.

Reduction by traction and direct pressure is generally easy, and it is generally well to keep the thumb extended and abducted for some time to prevent recurrence.

Dislocations of the *other metacarpals* are not common; the four metacarpals of the fingers have occasionally been displaced simultaneously backwards or forwards, and all five metacarpals together have been displaced forwards.

Dislocations of the thumb and fingers are fairly common, particularly those of the thumb **at the meta-carpo-phalangeal joint.**

Dislocation of the proximal phalanx of the thumb backwards is common. It may be incomplete or complete. The *incomplete* form can be produced voluntarily by many persons, or, like the complete form, may be due to hyper-dorsiflexion. The base of the phalanx rests against the posterior margin of the head of the metacarpal, while the anterior or glenoid ligament of the joint, carrying with it the sesamoid bones, is stretched over the head of the metacarpal bone. The phalanx is held in a position of marked dorsiflexion by the tension of the portions of the adductor and abductor muscles attached to the phalanx, and reduction is easily accomplished by traction and flexion of the phalanx.

When the dislocation is *complete,* the phalanx is carried right on to the dorsum of the metacarpal bone from which it projects at right angles. The head of the metacarpal bone projects through a tear in the front of the capsule, but that portion of the capsule in which the sesamoid bones are embedded, and which is strengthened by numerous transverse fibres connecting the sesamoid bones, often remains attached to the base of the phalanx, and so is drawn over the head of the metacarpal bone until it slips up to encircle its neck posteriorly,

while the tendons of the flexor brevis, attached to the sesamoid bones, encircle the neck on either side, the head thus projecting as it were through a buttonhole composed of untorn portion of glenoid ligament and sesamoid bones posteriorly and flexor brevis laterally, together with the tendons of the adductor and abductor, the tension of which latter muscles tend to preserve the phalanx in its position at right angles to the metacarpal bone. The lateral ligaments are generally torn, and the tendon of the flexor longus pollicis may be tightly stretched across the head of the bone, or pass to one side, generally the inner.

The condition is easily recognised, the first phalanx of the thumb being fixed at right angles to the metacarpal, in dorsiflexion, while the terminal phalanx is flexed on the proximal. There is a projection at the base of the proximal phalanx anteriorly due to the head of the metacarpal bone. The phalanx can be rotated, and turned to either side or downwards, but the latter movement should be avoided as likely to complete the buttonhole action if not already established.

Treatment where the buttonhole action is not complete may be easy. Relax the short muscles retaining the phalanx in its position at right angles by pressing the metacarpal toward the palm. Then, while keeping the phalanx in its right-angled position, push its proximal end down until it is on a level with the head of the metacarpal, and then flex. If, however, the glenoid ligament has got fixed behind the head of the metacarpal, it will not come forwards, nor permit the phalanx to do so. In such cases an anterior vertical incision may be made over the projecting head, the wound retracted, the glenoid ligament divided so as to permit of separation of the sesamoid bones and sides of the buttonhole, and then reduction is easy. The operation might be done subcutaneously by a tenotome. In unreduced cases the deformity persists and the joint is destroyed, but the thumb may still be useful.

Dislocation forwards is not common, is generally due to forcible hyperflexion, and is easily reduced. The posterior and lateral ligaments are torn, and the base of the phalanx lies in front of the head. The glenoid ligament, sesamoid bones, and muscles connected therewith are intact. The extensor tendons may be stretched over the head or displaced laterally.

The head of the metacarpal forms a projection posteriorly, while the base of the phalanx forms one anteriorly. The thumb is generally slightly flexed, but may be straight. Treatment is by forced flexion, aided if necessary by pressure on the base of the phalanx downwards.

Dislocation laterally has occurred to the ulnar side.

Dislocations of the fingers at the metacarpo-phalangeal joints are not nearly so common as those of the thumb.

Displacement is more often backwards, the cause generally forcible dorsiflexion, and the forefinger is most frequently affected. The condition is analogous to that in the thumb, the anterior glenoid ligament being thick, sometimes containing a sesamoid bone, and tending to go backwards with the phalanx and engage in the neck of the metacarpal, hindering reduction. The finger, extended or slightly flexed, is shortened, the base of the phalanx forms a prominence behind, and the head of the metacarpal a prominence in front. Treatment by traction and flexion. If this does not succeed, then by operation as for the thumb.

Forward dislocation is generally due to a blow. The finger is shortened, extended or slightly flexed, and often deviated to one side. The prominence of the base of the phalanx in front and of the head of the metacarpal behind is marked. Reduction may be accomplished by traction, perhaps with flexion and direct pressure.

The **middle phalanges** may be dislocated backwards, forwards or laterally. The backward form is generally caused by a fall on the palmar aspect of the extended finger, and the affected phalanx may remain at right angles to the proximal one, or become straight. As

the joint somewhat resembles that of the metacarpo-phalangeal of the thumb, it may be treated in a similar manner. Dislocations forward may be complete or incomplete and are easily reduced as a rule by traction and direct pressure. Lateral dislocations are rare.

Dislocations of the **terminal phalanges** are generally backwards, caused as a rule by a blow on the point of the extended finger. The anterior ligament, in the case of the thumb, is generally torn from the proximal phalanx, but in the case of the fingers from the distal one. The flexor tendon may be torn or displaced, but the lateral ligaments generally remain intact. The terminal phalanx may be straight, flexed or hyper-extended. The structure of the joints sufficiently resembles that of the metacarpo-phalangeal of the thumb to warrant attempts at reduction on the same principle.

A few cases of forward dislocation have been observed in the thumb, and a few cases of lateral dislocation have been reported.

Pelvis.

Separation at the pubic symphysis may be due to direct violence, forced abduction of the thighs, or to difficult labour. The separation may occur through the junction between bone and cartilage, and not through the cartilage.

Separation at the sacro-iliac joint, without fracture, is rare. A few cases of dislocation upwards of the innominate, from falls on one foot, with separation at the pubic and sacro-iliac joints have been recorded.

The *coccyx* may be dislocated forwards, backwards, or, very rarely, laterally. Dislocation forwards is generally due to direct violence, and gives rise to severe pain, which may cause fainting. The pain radiates down the thighs, and sometimes upwards to the head and shoulders. There is frequency of micturition, and pain on defaecation. The local pain remains severe, and is increased by coughing, or even ordinary respiration.

If unrelieved the health may suffer and the mind become dulled.

Externally there may be swelling and ecchymosis over the region, while the finger introduced per rectum detects the sharply projecting coccyx, which is easily reduced by hooking downwards, whereupon all the symptoms generally disappear immediately. Recurrence, however, is common. Backward dislocation, rarely caused during parturition, gives rise to similar symptoms, which likewise generally disappear on reduction.

Hip.

The chief dislocations of the hip may be classified according as they are backwards, on to the dorsum, or toward the sciatic notch: or forwards, on to the pubes, or into the obturator foramen. There are numerous rare subdivisions. Dislocation of the hip occurs more often during middle life, particularly in males, as the result of severe indirect violence, such as a fall from a height. The head of the femur generally leaves the socket at the lower and posterior part, where it is most shallow and the capsule weakest. As the inverted Y-shaped ligament of Bigelow (ilio-femoral) is generally not torn, and exercises considerable effect on the position of the limb, it should be remembered that it has its origin below the anterior inferior spine, its limbs diverging to be inserted into the anterior edge of the great trochanter and the anterior intertrochanteric line close to the small trochanter.

Dislocation on to the dorsum is by far the most common dislocation of the hip. The cause is generally a fall from a height, or a fall of a heavy weight on the shoulders, while the limb is flexed, adducted, and rotated inwards.

The capsule is torn below and behind as a rule, but sometimes the tear is entirely posterior. The anterior portion of capsule with the Y-shaped ligament remains

(1) Dislocation of wrist backwards.
(2) and (4) Dislocation of wrist forwards.

intact. The ligamentum teres is torn from the head of the femur, or ruptured. The quadratus femoris, gemelli, pyriformis and obturator externus are more or less lacerated, while the obturator internus may escape and the glutei generally do so. The head of the femur acted upon by the short lever of the neck, and the long lever of the shaft, with the Y ligament as a fulcrum, is forced through the capsule inferiorly and then, having escaped from the acetabulum, runs round it posteriorly till it comes to rest on the dorsum, above and anterior to the tendon of the obturator internus. The great trochanter is directed forwards and the head of the bone looks backwards.

Less frequently the head on emerging from the acetabulum passes below the obturator internus and then rises behind it, the muscle being interposed between it and the acetabulum and checking its ascent, the so called *Sciatic Dislocation*, or dislocation below the tendon, being produced. The sciatic nerve generally lies behind the head of the femur and escapes injury.

Symptoms. The limb is in a position of flexion, adduction and inversion and the only movements permitted are those which exaggerate the deformity. The gluteal fold is elevated, the buttock fuller than normal, and the great trochanter is above Nelaton's line. There is shortening of about 2 inches when measured from anterior superior spine to adductor tubercle with the thigh flexed at a right angle and adducted.

In the sciatic, below tendon, variety, the flexion and inversion are frequently greater than in the dorsal variety, but the flexion may be masked by tilting downwards of the pelvis, a compensatory lordosis developing.

The *diagnosis* is generally easy from above symptoms, and the condition should not be mistaken for a fracture of the neck, in which the limb is straight and everted and easily movable. In dislocation the tissues over Scarpa's Triangle are relaxed, enabling the fingers to be pressed deeply in, whereas they are tense in fracture.

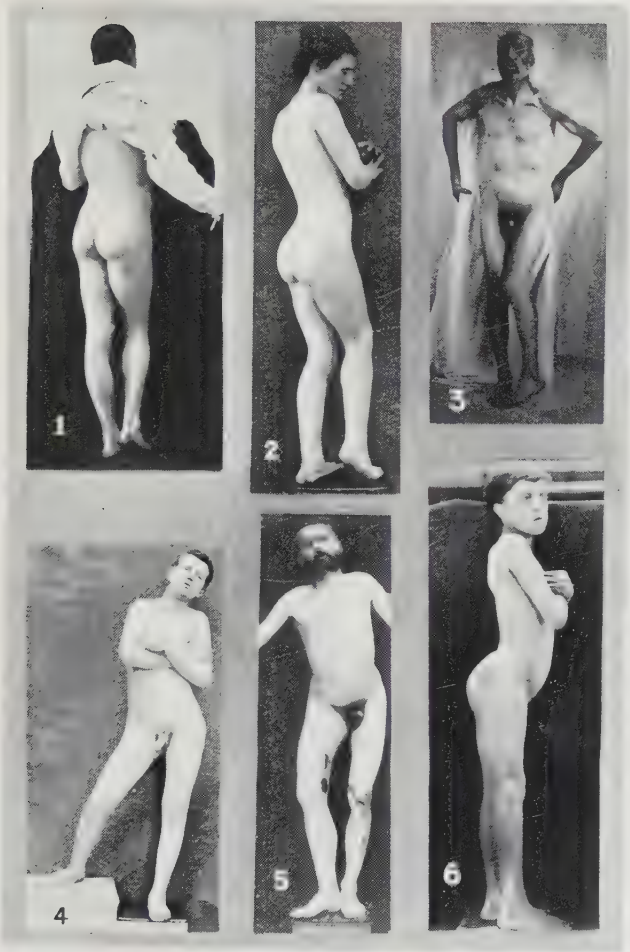
A few cases of *everted dorsal dislocation* have been recorded in which as a rule the outer branch of the **Y** ligament has been ruptured. The head may be supra-spinous—in the notch between the anterior superior and inferior spines. When the head lies in this position, the symptoms are quite different from those of an ordinary dorsal dislocation, the limb being generally straight and everted, while it may also be abducted. Shortening from 1 to 2 inches is present. The greater rigidity of the limb, the position of the head, and its movement with the thigh, should enable a diagnosis from fracture of the neck to be established.

Reduction is generally accomplished by laying the patient on a mattress on the floor; anaesthetising, and having the pelvis held firmly in position by an assistant. The deformity is first exaggerated by flexing the thigh on to the abdomen, in a position of adduction and inversion. This relaxes the **Y** ligament. The limb is next abducted and everted, while maintaining the flexion, thereby making the head retrace its course, while relaxing the rotator muscles and opening the rent in the capsule. A lifting movement or vertical traction may now make the head enter the acetabulum, but, if not, the limb should next be brought quickly down into the extended position.

Bigelow recommended (1) Flex and forcibly lift; if this fails, then (2) Flex and lift while abducting; if this fails use (1) over again.

Stimson recommends placing the patient face down on a table with the lower limbs projecting over the end, the sound limb being supported by an assistant in the horizontal position while the affected limb is allowed to hang vertically downwards. The surgeon grasps the affected ankle and raises it, flexing the knee to a right angle, and if the weight of the thigh be not sufficient to give the necessary traction, a weight may be suspended from the knee. When the muscles relax the surgeon imparts a slight rocking or rotation of the

PLATE XX.



(1) and (2) Dislocation of Hip on to Dorsum.
(3) Dislocation of Hip on to Dorsum (sciatic).
(4) Dislocation of Hip into Obturator foramen.
(5) Dislocation of Hip on to Pubes.
(6) Congenital Dislocation of Hip.

limb and reduction occurs as a rule without effort and often without anaesthesia.

Dislocation downwards and inwards to the **obturator or thyroid foramen** comes next in frequency to that on to the dorsum, but is very much less common. It is generally caused by a severe blow on the back while the limb is flexed and abducted. The capsule is ruptured below and to the inner side, the pectineus is lacerated, and the obturator externus may be likewise lacerated or pushed before the head, which comes to rest in the obturator foramen or on the ramus beyond it.

Symptoms. The limb is flexed, abducted, and generally everted, though this may be absent and even a degree of inversion be present. The limb has an appearance of great lengthening due to tilting of the pelvis downwards on the affected side to compensate for the abduction. Actually it is about the same length or slightly lengthened when the limb is straight, but is shorter when it is flexed and abducted. The great trochanter is lowered and displaced inwards, the buttock appearing rather flat, and the head of the bone can generally be palpated in its new position.

In some cases the patient has been able to walk immediately after the accident, so that in one case he only sought advice after a time on account of inability to fully adduct the limb, and in unreduced cases a new joint may form in the obturator cavity and the patient walk very well.

Treatment is generally by laying patient on a mattress as before; anaesthetising, and first exaggerating the deformity by flexing, abducting beyond the side, and everting; then adducting and rotating inwards, and finally extending. Lifting movements are also of assistance.

Reduction some weeks after injury has been effected by Kocher by applying continuous extension in the axis of the limb together with lateral traction outwards on the upper part of the thigh. Reduction occurred in about four days.

A few cases of *perineal dislocation* have occurred, which may be regarded as exaggerations of the obturator type. The thigh is generally flexed and abducted beyond a right angle. The rounded head of the femur may be felt in the perineum, where it may press on the urethra and cause retention of urine, while it may also be compound.

Reduction may be affected by flexing and rotating outwards, under an anaesthetic, then making traction, and finally lowering and rotating inwards.

Dislocation upwards and forwards and **inwards and forwards.** These forms are generally known as **supra-pubic** dislocations, the head of the bone lying most frequently upon the iliopectineal eminence, but sometimes further in, close to the pubes, and rarely the head may project into the abdomen, tearing Poupart's ligament, while the neck rests on the pubic ramus. The cause appears to be hyperextension ; or abduction and external rotation. The capsule is generally torn above and in front and the head passes under the ilio psoas, the vessels, and sometimes the pectineus.

Symptoms. When the head lies upon the iliopectineal eminence the limb is markedly everted but only slightly abducted, if at all; it is slightly shortened, and the head may be felt in the groin with the artery in front of it or to its inner side. When the head is displaced further inwards, the limb is distinctly flexed, abducted and everted, somewhat resembling the position in obturator dislocation. The head can be easily felt and may be seen above the pubis, and the vessels lie to its outer side. In both forms the hip is flat posteriorly, and the trochanter lies opposite the acetabulum. The presence of the head in the groin, and its moving along with the limb, serves to differentiate from fracture in case of doubt. In some cases the patient has been able to walk after the accident.

Reduction may be accomplished by the same method as for the obturator dislocation—flexion with abduction ; rotation inwards and adduction, and extension.

Kocher recommends (1) Traction in axis of limb; (2) pressure with hand to prevent return of head during (3) flexion; (4) rotation inwards.

A few cases are reported of upward dislocation of the head—*supracotyloid*—in which the upper part of the capsule was torn, the upper limb of the **Y** ligament being ruptured; and of dislocation downwards on to the tuberosity of the ischium—*infracotyloid*—probably an arrest, in the first stage, of an ordinary dislocation on to the dorsum.

After reduction of a dislocation of the hip the patient should be kept in bed for three weeks, massage and passive movement being given from the first, avoiding the position in which the particular dislocation was likely to have originated. Active movements, taking the same precautions, may begin at the end of a week.

As attempts at reduction of *old standing dislocations* are not free from danger, it is often wise to leave the limb unreduced if the patient can walk fairly well, and is not suffering pain. Reduction by manipulation must not be violent, and probably extension applied continuously for some days, at least as a preliminary, is best. *Operative treatment* may take the form of arthrotomy, Dollinger advising an incision from the posterior inferior spine to the base of the great trochanter. The gluteus maximus is retracted; the limb rotated inwards; the pyriformis and obturator internus retracted or divided; the acetabulum cleared, and the head replaced by manipulation. If this fails, the head may be excised. Excision of the head or osteotomy of the neck is generally easier and reasonably successful.

The hip is a frequent site of **pathological and congenital dislocations.**

Pathological dislocations are generally on to the dorsum, and are most often due to tubercle, but may also be due to rheumatoid arthritis and locomotor ataxia.

Distension of the joint, as from acute rheumatism,

and paralysis of certain groups of muscles, leaving others unopposed, are also occasional causes.

Charcot's Disease is one which frequently affects the hip or knee, in locomotor ataxia, and which is therefore painless. The joint becomes rapidly distended, and this may lead to dislocation within a few days of onset. Marked atrophy of the head of the femur, with almost simultaneous formation of masses of new bone in the capsule and synovial fringes, occurs, and these masses may become fused.

In young persons, and particularly females, the occurrence of a "*hysterical joint*," in which the attitudes of hip disease or dislocation may be simulated should be borne in mind. There is generally marked superficial tenderness of the skin over the suspected joint, and the movements are perfectly free under an anaesthetic.

A few cases of *voluntary dislocation* of the hip—where the patient could dislocate and reduce the head of the bone at will—are reported.

Congenital dislocation of the hip is fairly common, particularly in females. The cause of the condition is uncertain, being variously attributed to violence in utero or at delivery; muscular spasm; softening of the ligaments, hydrarthrosis; defective development of the head of femur and acetabulum, etc.

As a rule the dislocation is on to the dorsum. The acetabulum is ill formed and frequently communicates with a second depression higher up; the capsule is strong but enlarged; the ligamentum teres stretched, the head of the bone atrophied, and the neck short.

The condition is often bilateral, and the head moving between the position of the normal socket and the abnormal one, when weight is put on it at each step, gives rise to a curious slip to either side alternately as the patient walks. The pelvis is tilted downwards in front, and there is marked lordosis of the spine, with consequent protuberance of the abdomen. In unilateral

(1) Congenital Dislocation of Hip.
(2) Pathological (tubercular) Dislocation of Hip.
(3) Pathological (Charcot's disease) Dislocation of Hip.
(4) "Hysterical" Hip.

cases the patient walks with a limp; the pelvis is tilted forwards and downwards and there is consequent lordosis and scoliosis of the spine. In the majority of cases of both types the adductor muscles are very tense, and successful results are often obtained by placing the affected limbs in extension, together with abduction, the adductor muscles being massaged regularly, and the abduction steadily increased. Occasionally it may be necessary to partially tenotomise or lengthen some of the adductor tendons. Where this treatment does not yield sufficiently satisfactory results, the hip may be excised, and the acetabulum deepened, and the limb put up in extension and abduction for three or four weeks, after which active and passive movements are used freely to prevent osseous anchylosis between the bone surfaces.

Knee.

Dislocation of the knee is not common, is frequently caused by great violence, and is not infrequently compound, while the popliteal vessels may be seriously damaged.

Dislocation is most frequent **of the tibia forwards**, due to direct violence or to hyperextension.

Where the dislocation is *incomplete*, the posterior portion of the tibial articular surface being in contact with the femoral condyles, the laceration may be confined to the anterior crucial ligament. Where it is *complete*, the ligaments, posterior muscles, the popliteal vessels and nerves, and sometimes the skin are severely lacerated or torn. The artery may only be pressed upon, and be able to resume its function when the pressure is relieved; or it may be so damaged that a thrombus forms after relief of pressure; or it may be torn. The vein is less frequently torn than the artery, but it may also thrombose. When both artery and vein are affected, and particularly if the nerves are also damaged, gangrene is very likely to ensue.

Symptoms. The limb is generally extended, but may lie in almost any position, while in the complete form the damage is often so extensive that the tibia can be moved in any direction, the dislocation being rendered forwards, backwards or lateral at will. In the less extensive forms the condyles of the tibia form a projection in front, with the patella above them, the skin lying in a series of transverse folds, while the condyles of the femur form a prominence behind.

Treatment. In the slighter forms reduction may be accomplished by acute flexion or by traction combined with direct pressure. In the more severe forms the bones can be laid in position and must be maintained by a splint. *Compound forms* should be treated in the same manner as compound fractures, and amputation should not be resorted to unless blood and nerve supply have been obviously cut off. Generally it is wise to await signs of gangrene before amputating.

Recovery often occurs, but generally with weakness and limitation of movement, while anchylosis is not infrequent in the more severe forms which recover without amputation.

Dislocation **of the tibia backwards** is generally due to direct violence, and may also be incomplete or complete. The ligaments and muscles may not be so extensively injured in this form, but the vessels are frequently seriously damaged by stretching across the sharp posterior margin of the tibial condyles.

Symptoms. The limb is most often hyperextended, and may also be deviated laterally. The condyles of the femur project in front, with a marked depression beneath them, while the patella may lie on the projecting surface of the condyles or to one side. The head of the tibia forms a marked projection behind.

Reduction may be by flexion, or by traction and direct pressure, and is generally easy. The prognosis is generally good in uncomplicated cases, and cases have been reported where, subsequent to non-reduction, and rarely

PLATE XXII

Genu Recurvatum.

with the formation of a false joint, the patient has had fair use of the limb.

Lateral dislocations of the knee are very uncommon.

Dislocation outwards has occurred in a few cases and may be either complete or incomplete. The cause is generally forced abduction. The internal condyle of the femur projects on the inner side, and the external tuberosity of the tibia on the outer, the amount of prominence varying with the extent of the displacement. The position of the limb varies. Treatment is by traction and direct pressure.

Dislocations inwards, complete or incomplete, are very rare.

Dislocations by rotation are likewise very rare, a few cases of rotation outwards, and one or two inwards, having been reported.

Pathological dislocations of the knee are most frequently due to tubercle, the tibia being displaced backwards and slightly upwards, as a rule. They are much less frequently caused by rheumatoid arthritis and *Charcot's Disease.* A curious condition variously described as congenital dislocation of the knee forwards, and as *genu recurvatum*, is rarely met with. The knee is hyperextended, or, as in the case figured, entirely dorsiflexed, the child standing on the calves of its legs, and generally walking backwards. The patella is small in a young child, but in this case it was hardly perceptible. The case was easily cured by flexion under an anaesthetic and placing the limbs straight in plaster for a few weeks. Thereafter the child was not allowed to hyperextend, and soon could not do so.

The *semilunar cartilages*, as their name implies, are two crescentic cartilages which, lying on the articular surface of the head of the tibia, deepen the cups for the reception of the condyles of the femur. They are firmly attached at their extremities in front of and behind the spine of the tibia, while their thick circumferential borders are loosely attached to the margins of

the tuberosities of the tibia by the coronary ligaments and reflections of synovial membrane. The inner border is concave, thin, and free. The upper surface is slightly concave, and the lower is flat; both are covered with synovial membrane. The external cartilage is more nearly circular and more freely movable than the internal, and it is separated posteriorly from the external lateral ligament by the popliteus tendon, whereas the internal is attached to the internal lateral ligament and the semimembranosus tendon.

The cartilages move backwards on flexion, and forwards on extension, and laterally on rotation, which is permitted during partial flexion, the tibia rotating beneath the cartilages.

Abnormal laxity of the ligaments of the joint tends to undue mobility of the cartilages, which may become nipped between femur and tibia and so be detached or torn, or if the displacement be greater, become dislocated. *Rheumatoid arthritis* is very frequently associated with the condition and is probably a predisposing cause. It is frequently met with in younger adult males, particularly footballers, or those who kneel or squat during work, as in mining.

Dislocations of the cartilages: "Internal derangements of the knee" (Hey); or "subluxations of the knee" most frequently affect the inner. The cartilage having become unduly mobile by stretching of the internal lateral and coronary ligaments, slips backwards during some movement of flexion, combined with abduction, which tends to separate femur and tibia on the inner side, and may get caught between the bones and cause locking, or slip past the condyle and become lodged in the intercondyloid notch. The exact cause appears to vary, extreme flexion, slight flexion combined with external rotation of the tibia, or a violent jerk, being cited.

Symptoms. The patient may hear or feel something give way in the knee, severe sickening pain being produced, with locking of the joint generally in a slightly

flexed position; marked tenderness to pressure over the position normally occupied by the outer border of the cartilage, and followed by swelling. Passive flexion is generally permitted to a considerable extent, but extension is very painful. Where the condition is only one of partial displacement it may disappear during manipulation, but more often it persists. The cartilage may be felt to project on the inner side (in which case a pressure pad may be worn), or it may be absent, or no definite change may be palpable.

Reduction is attempted by (1) full flexion, (2) abduction (to separate internal condyle from tibia) and external rotation, (3) rapid extension while maintaining (2). The process may require to be repeated, possibly under an anaesthetic. Sometimes the cartilage returns with a distinct snap, but frequently there is no indication that reduction has been accomplished save that extension is once more easy and painless. *After reduction* the limb is placed between sandpillows, and massage and passive movement given regularly, rotatory movements being carefully avoided. The patient may begin to use the limb after about a month, using a stick in walking, and being very careful not to twist or strain the knee for some considerable time.

In some cases of displacement, and in many where the cartilage is torn, the patient has *recurrent attacks of locking* of the joint with subsequent swelling, the symptoms being practically those of a loose body in the knee. In such cases it is generally best to open the joint and remove the affected cartilage. Massage and passive movement should be begun once the wound is healed, and the patient may get up in about three or four weeks, an elastic bandage being worn for a week or so after rising.

Patella.

The patella may be dislocated outwards, inwards, or turned upon its edge. **Dislocation outwards** is the

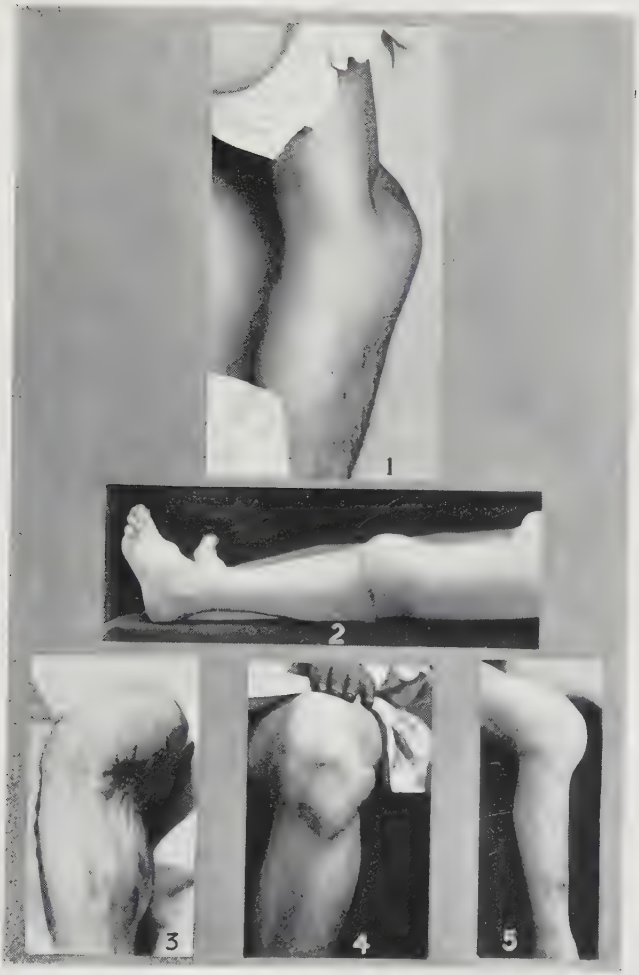
most common, and may be complete or incomplete. It may be due to direct violence, such as a blow, or to muscular action, aided frequently by hyperextension of the knee, but occasionally by flexion; extreme external rotation of the leg; or abduction of the leg. The condition is occasionally met with in cases of genu valgum.

In the *complete* forms the patella rests with its articular surface against the outer surface of the condyle, and it may maintain its normal relation to its vertical axis, in which case its inner border alone rests against the condyle, while the bone as a whole projects directly out laterally from it; or it may be rotated on its vertical axis so that its inner border is directed forwards and its non-articular surface looks outwards (the most common variety); or it may be rotated so that its outer border is directed forwards. The internal lateral patellar ligament is torn, and the vastus internus may also be lacerated.

The *incomplete* forms generally occur when the knee is extended, the patella resting on the outer and upper portion of the patellar facet of the femur.

Symptoms. In both forms there is pain, deformity, and loss of active movement. Passive extension is generally permitted, but increase of flexion is painful. In the complete forms the knee is generally flexed, but may be extended, particularly in incomplete forms. The patella can generally be seen, and is easily felt in its new position, with the quadriceps tendon and ligamentum patellae forming tense bands under the skin. In the incomplete form the patella may likewise be recognised above and to the outer side of its normal position, while the non-articular surface looks directly forwards or slightly outwards.

Treatment is by extending the knee and flexing the thigh, so as to relax the quadriceps, traction being made upon the muscle, if necessary, to increase the relaxation of the tendon. The bone is then pushed into position. The usefulness of the limb varies greatly in



(1) Dislocation of knee; Tibia forwards.
(2) ,, ,, ,, Tibia backwards.
(3) ,, ,, ,, Tibia outwards.
(4) ,, ,, Patella, outwards.
(5) Charcot's disease of knee.

unreduced cases, and, where necessary, the condition may be corrected by operation. **Dislocations inwards**, complete or incomplete, are rare.

Numerous cases are on record of *dislocation of the patella* **on its vertical axis**, due to muscular action or direct violence. In these cases one border of the patella is lodged in the depression between the condyles, while the bone is maintained projecting at right angles to its normal position by the tension of the capsule and other soft tissues. The anterior surface of the bone may face either inwards or outwards, the two forms being about equal in number. The knee is generally extended, but may be slightly flexed, and is generally fixed, while the projecting edge of the patella forms a distinct prominence.

Reduction by extension of the knee, and flexion of the hip and manipulation may be tried, or, if this fails, forcible flexion of the knee, or, under anaesthetic, slight flexion, manipulation, and then sudden extension may succeed. A few cases of *complete reversal of the patella* have been reported, as well as of *displacement downwards with rotation* on the transverse axis, the upper or lower border of the patella becoming wedged between femur and tibia. A few cases of *congenital dislocation*, generally outwards, are on record.

Fibula.

Dislocations of the fibula, apart from fracture, are uncommon. *Dislocations of the upper end* may be forwards, in which case they must also be outwards, as the articular facet is behind the most prominent part of the head of the tibia; or backwards. The cause may be direct violence or muscular action. In the forward type the head of the fibula forms a prominence in front of its normal position, while the biceps tendon is also prominent. Displacement backwards has sometimes been accompanied by eversion of the foot.

Reduction has generally been effected by flexion of the knee and direct pressure on the head of the bone.

Dislocation of the whole bone upwards has been reported, and a few cases of dislocation of the *lower end* of the bone, generally backwards, are on record.

Ankle.

Dislocations about the ankle include those in which the astragalus, carrying with it the foot, is displaced, and those (subastragaloid) in which the foot is displaced while the astragalus remains in position.

The astragalus, carrying with it the foot, may be displaced forwards, backwards, inwards or outwards.

Dislocation forwards, which is very uncommon, may be caused by dorsiflexion of the foot, with pressure of the tibia downwards and backwards, or by pressure upon the foot forwards or on the tibia backwards, while the foot is at right angles to the leg. The foot is generally in a position of plantar flexion, and is lengthened in front, while the heel is shortened behind, the hollows on either side of the tendo Achillis being obliterated. The malleoli are nearer the sole and heel than normally, and the upper surface of the astragalus may be felt projecting in front of the tibia. *Treatment* is by traction and direct pressure.

Dislocation backwards is more common, and is generally caused by extreme plantar flexion. The anterior and lateral ligaments are ruptured, the astragalus slips back, the plantar flexion is corrected and the astragalus becomes fixed behind the tibia. The dislocation is frequently complicated by fracture of one or both of the malleoli, the external being most frequently affected.

The foot appears short in front, and the heel unduly prominent behind, the tendo Achillis forming a prominent curved ridge. The lower end of the tibia forms a prominence in front, and may become compound.

(1) Dislocation of ankle inwards with inversion and internal rotation of foot : no fracture.

(2) Dislocation of ankle inwards with fracture of bones of leg.

Reduction is by direct pressure, combined if necessary with traction.

Dislocation inwards is rare, and may be caused by violent inversion, as in the case illustrated, in which the patient in falling had the foot caught between the rungs of a ladder. The foot may be markedly inverted, and the astragalus form a prominence under the external malleolus, or the foot may be markedly rotated inwards, the toes pointing inwards at right angles to the leg. The dislocation is frequently complicated by fracture, generally of the external malleolus.

Treatment is by traction and forcible eversion.

Dislocation outwards is a regular accompaniment of Pott's fracture, and, apart from this form, is rare. A few cases have been reported of marked abduction of the foot—dislocation by rotation outwards—where the bones were not broken, and still fewer of marked eversion.

A few cases of *dislocation upwards* between tibia and fibula without fracture are on record.

In **sub-astragaloid dislocation** the calcaneum and cuboid are displaced from under the astragalus, which maintains its position. The more common displacements are backwards and inwards; and outwards.

Dislocation backwards and inwards is caused by forcible inversion and adduction of the foot. The head of the astragalus lies on the cuboid, while its posterior border rests in the grove between the two articular facets on the calcaneum. The calcaneo-cuboid joint may also be damaged.

Symptoms. The dorsum of the foot is shortened, the heel lengthened, and the front of the foot adducted and inverted. The external malleolus and head of the astragalus form a prominence on the outer side.

Dislocation outwards may be due to forcible abduction, in which case the foot turns on the interosseous calcaneo-astragaloid ligament, and the scaphoid is carried to the outer side of the head of the astragalus; or it may be caused by abduction and eversion, or by direct

violence, in which case the foot is displaced bodily outwards from beneath the astragalus, the head of which may rest against the inner side of the scaphoid or project through the skin. The calcaneo-cuboid joint may also be damaged.

Symptoms. In the first form the foot is markedly abducted and more or less everted, while the head of the astragalus forms a prominence on the inner side. In the second form the foot is displaced outwards with little abduction or eversion. The internal malleolus is prominent, with the head of the astragalus below and in front of it, while the normal prominence of the external malleolus is replaced by a depression.

Dislocations backwards and forwards are very rare.

Treatment consists in flexing the knee so as to relax the calf muscles, applying powerful traction, and direct manipulation. Even under anaesthesia reduction may be difficult.

Dislocations of the astragalus alone are more common than those of the foot, and may be due to falls on the feet or to violent twists of the foot.

Dislocation directly forwards is very rare, whereas dislocation *forwards and outwards* is the most common. The head in the latter form rests on the cuboid and outer cuneiform or base of the fifth metatarsal, and not infrequently projects through the skin. The foot is adducted and inverted, and usually displaced bodily inwards, rendering the external malleolus unduly prominent. In many cases the astragalus is also rotated on one axis or other and may be fractured.

Dislocation forwards and inwards comes next in frequency. The bone is generally also rotated on its transverse axis so that the head, in addition to projecting forwards, is also depressed, sometimes beneath the internal malleolus. The condition may be compound or complicated by fracture of the astragalus.

Dislocation inwards beneath the internal malleolus is very rare, but a number of cases have occurred of

dislocation *backwards*, in several of which the bone has been fractured at the neck and only the posterior portion dislocated. The bone pushes the tendo Achillis backwards or projects to one side of it, and may penetrate the skin.

Reduction by traction and manipulation is difficult.

The astragalus may also, while remaining more or less in its position between tibia and fibula, be *dislocated by rotation*, upon its transverse and vertical axis, so that the head projects beneath or even behind the internal malleolus, while very rarely it has rotated on its antero-posterior axis.

In cases where, with the assistance of an anaesthetic, reduction of the dislocation of the astragalus cannot be accomplished by manipulation or operation it may be excised.

Foot.

A very few cases of **mid-tarsal dislocation,** caused by great violence, have been reported, the head of the astragalus and the anterior end of the calcaneum resting upon the bones in front.

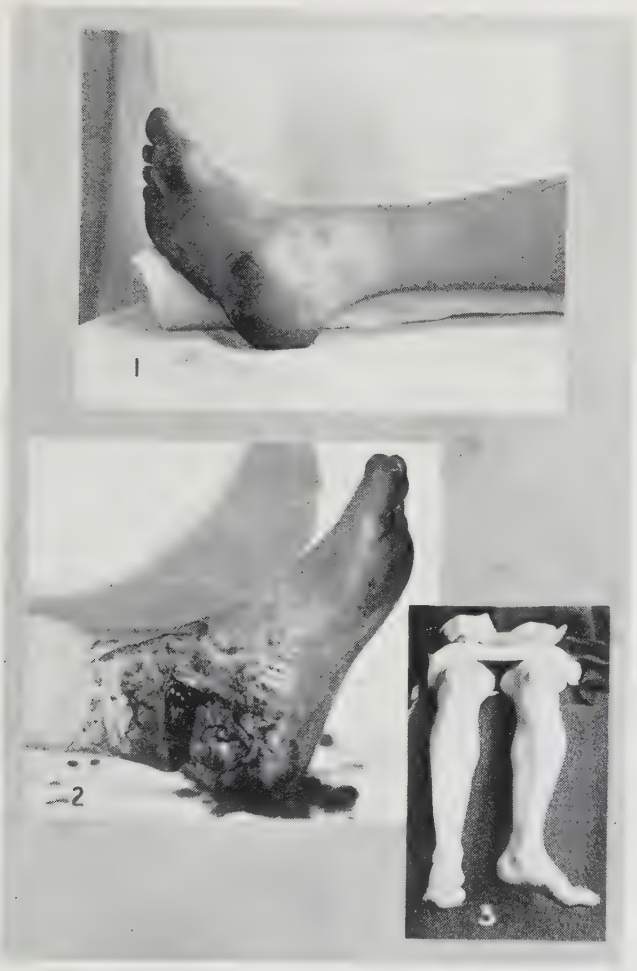
Dislocations of the individual bones of the foot have been reported, but apart from the astragalus are not common. The *scaphoid* is most frequently dislocated forwards and upwards on to the dorsum. The three *cuneiform bones* have been dislocated together, generally upwards, as have the second and third; several cases of dislocation of the first alone are on record.

Of the **metatarsal bones**, the first has most frequently been dislocated, and generally upwards, from direct violence, reduction being accomplished by traction and direct pressure. All the matatarsal bones together may be displaced, generally upwards or outwards, from direct violence or even muscular action, the condition generally being accompanied by fracture of some of the metatarsals, cuboid, or first cuneiform.

The *head of one of the metatarsal bones*, generally the fourth but occasionally the third, may be subluxated and give rise to metatarsalgia (Morton's Disease), which, in the severe forms may necessitate excision of the head.

The *great toe* has been dislocated by direct violence and falls on the toe, the displacement being generally backwards and outwards, when it has been compound as a rule. Less frequently it is backwards. Reduction has generally been accomplished by traction and direct pressure, but operation may be necessary. The *other toes* have been dislocated upwards and backwards or directly outwards.

The *terminal phalanx of the great toe*, and the second phalanx of the third toe have also been dislocated.



(1) Dislocation of Ankle backwards with separation of tibial epiphysis and fracture of fibula.

(2) Compound dislocation of Astragalus.

(3) Dislocation of Ankle by rotation outward.

AMPUTATIONS AND ARTIFICIAL LIMBS.

General Considerations.

In many cases of compound fracture accompanied by severe laceration of the soft parts, such as are caused by machinery accidents or shell or bomb wounds, the question of amputation must be considered. It is often a difficult one to decide: on the one hand amputation means permanent maiming, on the other there is the danger of loss of life from attempts to save the limb. In endeavouring to arrive at a decision, numerous factors must be taken into account, apart from the condition of the affected limb. The experience of the surgeon, the circumstances under which he has to act, and the facilities for treatment which he has at his disposal are all very important. An experienced surgeon, with his patient in a well-equipped hospital, may succeed in saving a limb, which under less favourable conditions must be sacrificed. The possibility of rendering the parts aseptic and maintaining them so is generally a determining factor. The health of the patient is also often a determining factor, a strong healthy individual making an excellent recovery, where one addicted to alcohol, or suffering from kidney disease or syphilis does not. Speaking generally, the particular limb affected may have an influence on the decision, as wounds of the lower extremity are often much larger than those of the upper; muscle is generally more extensively damaged with consequent

fall in blood pressure; they are more prone to acute infections of the gas gangrene type; present a larger area of absorption; while after amputation the loss of the lower limb can be much more efficiently compensated by an artificial limb that can that of the upper.

In considering the question of amputation it cannot be too strongly insisted on that *amputation is now a means to an end.* It is no longer merely a means of removing a diseased or damaged limb which threatens the patient's life, but it is one which has as its object the provision of a stump which, when fitted with an artificial limb, will restore in varying degree the usefulness of the damaged limb. Limb-making has made great strides recently, and may now well claim to be a science, but, if the best results are to be obtained, surgeon and limb-maker must co-operate. To aid in this direction is one of the objects of this chapter.

Two questions are generally uppermost in the surgeon's mind in such cases. (1) Is an amputation necessary, and, if so, when should it be performed, and (2) If it is to be performed, what point should be selected for the amputation, and what type of amputation should be chosen?

The question of amputation may arise either immediately after the accident or at a later stage. **Immediate amputation** is called for where there is no chance of saving the limb. In some cases, for example, the bone is shattered, the main vessels and nerves torn, the muscles abrupted, and the limb remains attached by portions of skin, tendon, and fascia. Removal of the damaged portion is the work of a few seconds with a pair of scissors. In other cases the bone is shattered, and the main vessels and nerves destroyed, and the muscles much lacerated, but while the injured portion is cold, blanched and pulseless, its attachments to the upper portion are still considerable. Here also amputation is demanded, and can generally be performed after disinfection with iodine or Harrington's solution by a few sweeps of the scalpel, and without an anaesthetic.

It may be well to remind the beginner that absence of bleeding is no proof that the vessels are intact. One often sees cases of terrible laceration and even avulsion of limbs where there is no bleeding whatever, partly because the patient is suffering from severe shock, but chiefly because the ends of the torn arteries have been twisted and curled up by the injury.

Whether a more formal amputation should be performed in such cases at the time will depend upon the condition of the patient and of the tissues above the point of detachment. Generally it is best to treat shock which is almost certainly present, and postpone further operative treatment till a later date, the open end of the stump being enveloped in a moist one to one hundred carbolic dressing, and regularly inspected lest haemorrhage occur.

Shock is a very serious condition, necessitating immediate treatment. When a patient is wounded or injured he may suffer from *primary shock* with collapse and fall of blood pressure, which tends to arrest haemorrhage. This primary shock may prove fatal, or may be transient and be followed by recovery, or be succeeded by *secondary shock* coming on perhaps some hours later. Secondary shock is generally much more serious; is accompanied by pallor, coldness, rapid superficial breathing and fall of blood pressure, and is often fatal. While the precise pathology of shock is doubtful, the condition appears to be always associated with *fall in blood pressure*, and when this is overcome, the other symptoms tend to disappear.

Loss of blood is certainly an exciting cause, and, while not the only one, is probably always present to some extent in traumatic cases. A patient may lose a very considerable amount of blood, however, without exhibiting shock, so long as certain other conditions are not present. These other conditions include exposure to cold, injury, particularly to muscle, deficiency in oxygen in the air breathed, and readmission of blood to parts after compression of the aorta or other large vessel. When

some of these conditions are present a comparatively slight loss of blood may be sufficient to produce symptoms of shock.

The *treatment* of shock is directed to combating the conditions which produce it, and must be carried out promptly and energetically.

Heat must be applied and endeavour made to produce sweating. This is most rapidly and effectively done by placing a large cage over the patient, with several electric lamps suspended from its interior, while the bedclothes are laid over the top. Where electricity is not available hot air may be supplied to the interior from a gas or paraffin stove, or, failing some such arrangement, the patient may be surrounded with hot water bottles wrapped in flannel.

The patient is generally very thirsty, and, if there is no abdominal injury, *hot water* with a little stimulant added may be given freely. Of much greater value, however, is the administration of *saline per rectum*. One teaspoonful of salt is added to a pint of warm water, and ten ounces or so are slowly run in, using a funnel, rubber tube, and rectal nozzle. If a rectal tube be used and a high injection given, larger quantities can generally be employed, and more rapid results obtained. These injections may be given every half hour at first, the interval extending to two hours as the patient improves. Continuous injection is advised by some, but the writer's experience is that it is much more troublesome to work, is no more efficient, and the patient does not like it. If thought desirable a little stimulant and a few drops of laudanum may be added to the salines. A solution of soda bicarb. five per cent. and glucose five per cent. may replace the saline. If further stimulation be required, *pituitrin* given hypodermically appears to be most efficient and lasting. Camphor is preferred by some as a cardiac stimulant.

At all times the patient must be *kept flat in bed*. If he be allowed to sit up fatal syncope may ensue. Some

advise the firm bandaging of the sound limbs so as to keep as much blood as possible in the trunk and head. In any case both trunk and limbs should be enveloped in cotton wool after patient has sweated freely and the electric cage has been removed.

The treatment indicated above is sufficient in many cases, but where following loss of blood, there is marked fall in blood pressure, **intravenous injection** may be necessary, and should not be delayed.

An *isotonic salt solution*, most easily made up from soloids of sodium chloride alone, or in combination with other salts, may be used. The solution is ·9 per cent. in strength, and may be made by dissolving seventy nine grains of pure sodium chloride in one pint of water, and must be thoroughly sterilized by boiling before use, and injected at about a hundred degrees Fahrenheit. While such a solution raises the blood pressure, the rise is generally temporary, owing, it is supposed, to diffusion of the fluid through the vessel walls into the tissues. The same objection applies to Ringer's solution.*

In order to overcome this difficulty, Bayliss devised a *gum saline solution* which closely resembles blood in its viscosity and in the osmotic pressure of its colloids. It may be made by placing a pint of water in a glass flask to which is added seventy-nine grains of pure sodium chloride and five hundred and twenty-five grains of pure white Turkey elect gum arabic in small lumps, and standing it in hot water until the contents are thoroughly dissolved, when the solution is filtered through flannel and returned to the glass vessel. The neck of the vessel is now plugged with cotton wool and the contents are boiled for fully half an hour by placing the flask in boiling water. It may be run at blood temperature into a vein

* Ringer's Solution—

Sod. chlor. -	·88 grm.
Potass. chlor.	·025.
Calc. chlor.	·02.
Sod. Bicarb.	·015.
Ag. Dest. ad.	100 c.c.

through an ordinary small sterile glass funnel, rubber tube, and glass nozzle or metal needle, the funnel being kept above the level of the vein and fifteen minutes being taken to run in the pint of solution. A second pint may be given if necessary half to one hour later.

While experimental research would seem to indicate that in most cases gum solution is a fair substitute for blood, and Bazett states that a patient has a fair chance of recovery so long as haemoglobin does not fall below twenty-five per cent., still practical experience seems to show that, at least in cases associated with much haemorrhage, **transfusion of blood**, when obtainable, is much to be preferred.

Over forty per cent. of people have blood the red cells of which are not agglutinated by the serum of the blood of any other person, and they are therefore described as *universal donors* and are placed in group four. About eight per cent., on the other hand, have blood the serum of which agglutinates the red corpuscles of no other person, and they are described as universal recipients, and placed in group one.

Between these two groups are two others—two (about forty per cent.), and three (about ten per cent.), whose sera agglutinate the corpuscles of one another and also those of group one.

Where possible, persons belonging to group four are chosen as donors, as then it is unnecessary to test the blood of the recipient.

To test the blood of a possible donor a drop of testing serum number two and a drop of testing serum number three (as issued by the War Office during the war) are placed at opposite ends of a glass slide, and a drop of the prospective donor's blood is mixed with each, and the result noted after a few minutes.

If no agglutination has occurred, the donor is group four :

If agglutination has occurred in both, the donor is group one.

If agglutination has occurred in number two the donor is group three.

If agglutination has occurred in number three the donor is group two.

While transfusion can be performed by the *direct method* from an artery of the donor to a vein of the receiver, the tubing and cannulae having been first sterilized and coated with paraffin wax dissolved in ether, it is usual to *citrate the blood.*

Method. A small incision is made if necessary in the skin of the donor over a distended vein at the elbow, and a large bore (2–2·5 mm.) metal needle is introduced. The blood is run direct into a sterile glass vessel containing 160 c.c. of a 3·8 per cent. solution of sodium citrate. The vessel is turned round constantly as the blood runs in, so as to mix the blood and citrate solution, but it should not be violently shaken lest the corpuscles be broken up. 660-860 c.cs. of blood are drawn off.

Citrated blood may be kept for several hours with perfect safety and has been kept much longer under proper precautions. It is run into the vein of the receiver at 40° C. through a funnel and tubing with needle or cannula as already described for saline or gum saline. The apparatus should first be filled with saline and the blood added once the flow is established.

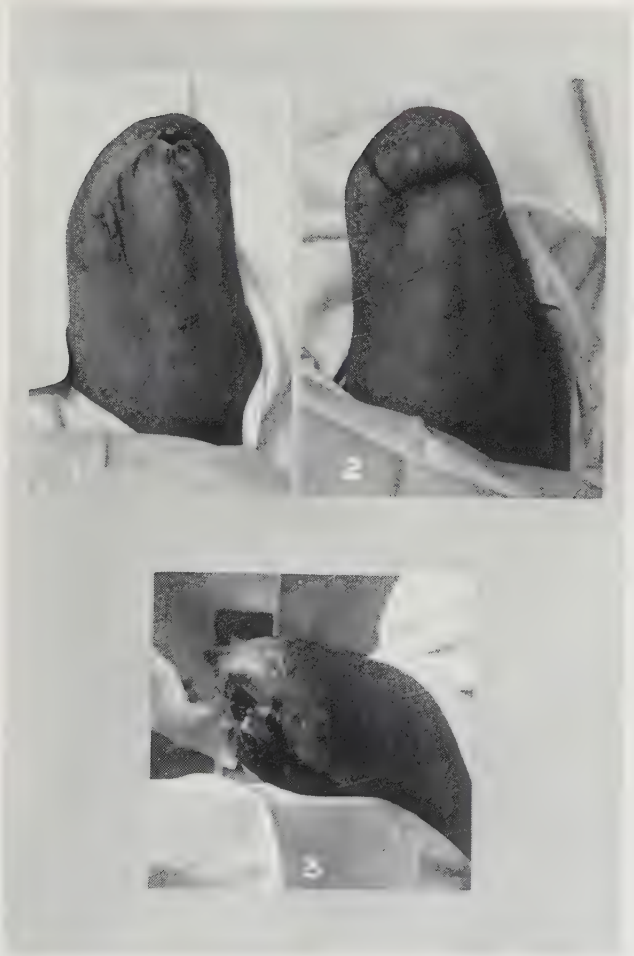
When the **damage is less severe** than that already described there arises the difficulty of deciding upon the line of treatment to be adopted. Speaking generally, it is *not wise to operate while shock is markedly present*, as amongst other reasons, anaesthetics, and particularly ether, diminish supply of oxygen to tissues, and operation generally tends to cause fall of blood pressure. The operation should therefore be postponed if possible until the condition has improved under the treatment already detailed. Where *early operation is essential*, and shock is still present, it is advised to give intravenous gum saline before and during the operation, and to use an anaesthetic which will minimise the deprivation of oxygen,

such as nitrous oxide and oxygen: ether is specially to be avoided. If the operation be for arrest of haemorrhage, the intravenous injection is best delayed until the source of haemorrhage has been found and dealt with.

As a rule amputation is safer than expectant treatment, but of course it entails permanent maiming. It is generally wise to explain the position to the patient, or to his friends if he be too ill, and let the decision rest with them. Where, however, the surgeon has had experience, and hospital treatment is available, expectant treatment may generally be safely carried out in the absence of clear indications to the contrary.

Where **expectant treatment** is decided on the wound should first be carefully cleaned out and rendered aseptic, all foreign matter and dead tissue being removed as already described in detail under treatment of compound fractures, save that no attempt is made to fix the bony fragments in position at this stage. The limb is then enveloped in a one to one hundred carbolic solution dressing, or, if preferred, the dressing may be confined to the site of injury and the rest of the limb enveloped in cotton wool. In any case the dressing or cotton wool should be laid lightly in position and not tightly bandaged so that the circulation will not be impeded. The limb should then be gently extended and slightly elevated and covered by a cage which keeps the weight of the bedclothes from pressing on the damaged limb.

The *patient's general health* requires careful attention. *Diet* for the first few days should consist of milk thoroughly pancreatised and given unboiled so that the ferment is still active. If given per rectum the pancreatising process should be carried on until the milk is bitter. Beef tea and chicken tea may also be given, stimulant as required particularly in alcoholics, according to state of pulse and not in a routine dose, while if the patient be restless, bromide in 5-10 grain repeated doses may be given by mouth or rectum. The bowels should be acted on by repeated small doses of castor oil or other aperient.



TYPES OF UNSATISFACTORY THIGH STUMPS.

(1) Slightly conical; wound will not heal; bone presenting at raw surface.

(2) A stump with well placed cicatrix, but cicatrix large and deep with eczematous margins and end flabby and somewhat bulbous.

(3) Adherent cicatrix; wound will not heal.

The urine should be repeatedly examined and if albumen or sugar be present appropriate medical treatment should be instituted.

The *temperature, pulse and respirations* should be taken every four hours and charted, and it must be remembered that a falling temperature combined with a rising pulse-rate generally indicates that something is seriously wrong.

The affected limb is regularly inspected as to recovery of *circulation and nerve impulse.* The pulse may be detected, or the nails may become pink, and blanch on pressure and immediately recover when the pressure is removed. Movement in the toes is not necessarily a sign of importance, as dead toes may be moved by dead tendons attached to living muscle above the point of injury. Sensation in the toes is of more significance. If the wound has been packed, the packing should be changed every twenty-four hours, and in any case the superficial dressing must be regularly changed and the wound inspected.

There is always the possibility in extensive crushes that, even although all obviously damaged tissue has been removed at the first operation, considerable areas have lost their vitality and will die and ultimately be separated as sloughs. Such changes must be looked for, and it should be remembered that necrosis may involve the coats of an artery with the result that *severe haemorrhage* may arise at any time. A tourniquet, preferably a stout rubber bandage, should always be at hand, and the nurse warned to watch for haemorrhage. If haemorrhage occurs the vessel may be ligatured, but it is often very difficult to find, and may necessitate either ligature of the main vessel higher up, with risk of subsequent death of the injured limb, or immediate amputation.

As soon as it is evident that the injured limb is not going to survive, or that extensive acute sepsis or gas gangrene is developing in the wound, **amputation** should be performed. One advantage of amputation at this stage is that shock has been recovered from, and the

upper limit of damage is more clearly defined. Speaking generally, as much healthy skin should be saved as possible. The skin flaps should include all the tissues down to the muscle, and should be raised by gentle traction and as little cutting as possible. Do not raise the skin-flaps far beyond the point at which it is intended to cut the muscles. If the spread of sepsis or gas gangrene is feared the *modified guillotine operation* may be employed, the muscles and bone being cut straight across, after which the wound should be lightly packed with sterilized gauze and the skin-flaps stitched in eversion, or pulled down by extension strapping with a weight of two or three pounds, to prevent retraction. As this operation generally necessitates a subsequent re-amputation it should only be used where there is grave danger of spread of infection. Wherever possible muscle-flaps should be cut and stitched over the end of the bone. In all cases the end of the bone as soon as cut should be covered with iodoform and boracic powder (one to five) which is pressed into the cancellous tissue and medulla of the cut end, partly to arrest haemorrhage and also to seal the parenchymatous tissue.

It sometimes happens that although a limb recovers, the *wound remains septic*. The sepsis is not virulent, but the patient is unable to overcome the infection. In some cases this may be due to portions of tissue, frequently bone, dying, and acting as a nidus for the organisms, and removal of the nidus generally leads rapidly to cure. Or again a pocket may develop which is not efficiently drained, and so acts as a breeding ground for the organisms, or the medulla of the bone may be affected. But there are some cases in which although all points of this kind have been attended to and cleared up, the slow sepsis persists and spreads, the tissues above and below the wound becoming oedematous, while the patient's health suffers. In such cases the writer has found that the cause is as a rule to be looked for in the patient's general condition.

Albuminuria and glycosuria have already been mentioned, but another important cause is *syphilis*. Where the syphilis is of the acquired type it is not likely to be overlooked, but where it is congenital, and the signs are not prominent, as is often the case, the condition may easily be missed. In many such cases the administration of grey powder has a marked effect in improving the patient's health and in overcoming the sepsis.

These cases of persistent sepsis are amongst the most difficult in which to decide as to amputation. The amount of discharge is slight, there are no acute inflammatory phenomena, the temperature is normal, the pulse generally but not always, distinctly above normal, and appetite defective.

In addition to attending to the general health on the lines indicated, a skiagraph should be taken to ensure that some fragment of bone or metal has not been overlooked. Unfortunately other foreign matter does not show in skiagraphs, as in a case under the writer's care where the patient was shot through a wallet in which he had his shaving brush. The greater part of the brush had been carried into the wound, and an exploratory operation had removed great numbers of the hairs, but not all. In such cases, before deciding on amputation, it is generally well to open the wound freely and make sure by visual inspection that everything has been removed, and then, if the wound does not rapidly improve, to amputate without delay.

In cases of persistent sepsis the writer has often deliberately amputated through oedematous tissues in order to obtain the advantages of some special amputation, such as a Syme; swabbed the end of the bone with iodine, and padded it with iodoform and boracic powder; then placed one end of a strip of gauze dipped in sterile camphorated oil over the end of the bone, and brought the muscles together by two or three sutures over the end of bone and the packing, the other end of which is left projecting. A dressing of gauze wet with one to forty carbolic acid

or camphorated oil is next applied over the sutured muscles, and the skin may be brought together by a few sutures, or preferably extended by extension plasters, and carefully stitched after the first or second dressing when it is certain that the underlying parts are doing well.

A similar condition of *persistent slight sepsis* is sometimes met with *after amputation*, particularly in war work. The causes are similar to those already referred to—a piece of dead bone or unabsorbable foreign matter being a frequent source of mischief. In many cases examined at Erskine one or more silk ligatures have been found to be the cause of prolonged suppuration and suffering. In such cases the sinus should be freely opened up and explored. On the other hand the patient's health may be at fault, and the possibility of hereditary syphilis particularly should not be forgotten, or there may be an *adherent cicatrix*.

Re-amputation is often the only satisfactory remedy, particularly where the cicatrix is adherent to the bone, and where this is decided on, the whole infected area including the end of the bone should be excised en masse by a deep elliptical incision. Care must be taken that infection of the sound tissues exposed does not occur from the infected ones removed, or from use of infected instruments for healthy parts. The cut end of the bone is dabbed first with iodine and then with iodoform and boracic powder; the muscles are stitched over it, and the skin then sutured.

Apart from sepsis several conditions may cause **tender stump** and may necessitate operation. Stump neuromata are a frequent cause, particularly after sepsis, and inclusion of a nerve in a cicatrix. In such cases excision of the affected portions is generally sufficient treatment. Tight stretching of the flaps of muscle or skin may produce marked tenderness and tendency to break down on slight pressure or injury and may necessitate removal of a piece of bone. A somewhat similar effect is produced

by outgrowths of new bone about the divided extremity of the bone which are sometimes very considerable, and by adherent cicatrix. In many cases the patient's general health requires attention while the condition of the limb as a whole may be improved by massage, whirlpool baths and electricity. In cases where the cause is doubtful, operation should only be resorted to after such treatment has failed.

Amputations in General.

Rules.

There are a number of points regarding amputations in general which the beginner must bear in mind.

While in certain amputations, as for example a Lisfranc or Syme, the standard operation, as described, should be closely adhered to, it is not necessary to slavishly follow the details of some particular operation in amputating, say, a forearm or thigh. The descriptions given should be regarded rather as suggestions and once the operator has had a little experience of standard operations he may regard each case on its own merits and act accordingly. There is no fixed right and wrong way of amputating at a certain level and what constitutes the 'best' method will often be a matter of opinion and will be governed by the circumstances of the case. Amputation by circular or modified circular skin-flap has a very general application.

(1) Plan the skin-flaps carefully before beginning so as to ensure their being ample both in length and breadth. **When in doubt err by making them too large.** They possess great power of retraction and can easily be trimmed if necessary. Where the amount of available skin is limited make use of all of it and thereby save as much bone as possible.

(2) In cutting the skin-flaps, cut straight down on to the muscles. Damage to the muscles at this point does not matter as they are ultimately cut at a higher level.

(3) In raising skin-flaps, carefully preserve the panniculus adiposus. Lift the flap with the fingers and do what cutting is required with the knife held at right angles to the muscles and at some distance from base of skin-flap.

(4) Don't raise the skin-flap more than an inch beyond the point at which the muscles are to be cut.

Fig. 52.
Method of raising skin flaps.

(5) Where possible cut good muscle-flaps which can be stitched over cut end of bone.

(6) While as a rule every available piece of bone should be saved, the flaps both of muscle and of skin must cover the cut bone without undue tension and preferably without any.

(7) Where periosteum can be saved and reflected and then stitched over the cut end of the bone it forms an advantageous covering which diminishes tendency to subsequent new bone formation.

(8) Want of attention to muscle flaps frequently leads to conical stump, adherent cicatrix, and loss of power.

(9) Where amputating in a child remember probability of bone growing in length and ultimately projecting through cicatrix.

Amputations of the Upper Extremity.

It should always be borne in mind that loss of the *thumb and fingers* cannot be adequately compensated. It is quite possible to supply a hand with moveable thumb and fingers, but even when the patient is able to move these at will, they have no sensation of touch, and the movements must be directed by sight. It is therefore very important to preserve the thumb and fingers wherever possible, and particularly the thumb and forefinger, or even parts of these.

The hand may first be soaked in one to twenty carbolic solution for half an hour, which not only disinfects the tissues, but also has an anaesthetic effect, and during this period of soaking, the wound should be washed out two or three times to remove blood clot and loose debris. The wound should then be carefully cleaned out on the lines already indicated, all pockets being explored, and dead or hopelessly crushed tissue removed. The hand should then be examined and a plan made whereby the utmost is done to utilise such skin as is left, and preserve the thumb and fingers. Many a case which looks hopeless at the first glance will recover with a maimed but useful hand, far better than any artificial one.

In *amputating a finger*, as in all other amputations, care must be taken to provide abundant skin-flap. This is best secured by making a straight longitudinal incision along the dorsum of the phalanx to be disarticulated to about its middle and then making a circular sweep inclined slightly toward the point of the finger on the palmar aspect. An incision through the web of the finger, as generally advised, leaves too little flap and leads to contraction. In the case of the *forefinger* and little finger a flap longer on the radial and ulnar borders

respectively is desirable so as to keep the cicatrix away from the surface to which pressure is applied when the hand is used.

In the case of the thumb and index finger even a portion of a phalanx is often of service.

It is generally well to unite the severed flexor and extensor tendons over the cut end of the bone or to the periosteum or other soft tissues at the point of section or to the proximal head in a disarticulation, before stitching.

Fig. 53.
Amputations of fingers.

The same conservative treatment should be employed throughout the hand and wrist, no standard amputation being performed but every available portion saved. A few cases have recently been recorded where, in order to compensate for the loss of fingers, and thumb, the great and one or more little *toes have been transplanted.* The operation is done in stages, the hand being fastened to the foot while the graft and sutured tendons on one side are uniting, the blood supply coming from the foot during this period. Successful results are claimed so far as movement is concerned, but nothing is said as to sen-

TYPES OF ARM STUMPS.

(1) Conical in boy. Growth of bone from upper epiphysis has caused projection of bone through skin.

(2) Disarticulation at wrist. Bulbous extremity prevents accurate fitting while there is no room for mechanism.

(3) Amputation close to shoulder.

(4) An excellent forearm stump.

sation. Of course the damage to the foot is very considerable.

A *disarticulation at the wrist* is not generally desirable. The patient loses all finger, hand, and wrist movement and the disarticulation at this point does not leave room for the introduction of mechanism of an artificial hand unless the limb be made longer than its neighbour. The seat of election is probably below the junction of the middle and lower third of the forearm. The **lower forearm** is a favourable site for a cuff flap of skin—a circular incision is made at the wrist, and a cuff of skin and panniculus adiposus is turned up by gentle traction aided by the knife which is kept vertical and makes

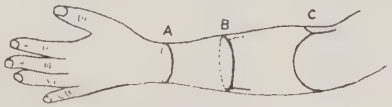


FIG. 54.—Amputations of forearm.
A circular. B circular, with short lateral incisions. C lateral flaps.

gentle sweeps at some distance from the point of reflection. The cuff may be modified if necessary by making two short lateral incisions upwards from the circular one in order to render the raising of the cuff easier. The muscles and tendons should be cut sufficiently long to enable them to be stitched together over the ends of the bones.

The Italians and Germans have during the war devised a method of making use of these muscles and tendons to provide *voluntary movement in the fingers of an articulated hand*, and some successes are claimed.

The method consists of making loops of the ends of the extensor and flexor tendons, which loops project slightly beyond the end of the stump, and they are covered with skin. When healed the stump has two or more projecting tags representing the looped extensor and flexor tendons covered with skin. The skin covering the loops is next pierced from skin surface to skin surface, the aperture

going through the tendon loop, and a piece of glass rod or other foreign body is inserted to prevent closure until the skin has grown through the aperture from either side, after which the hole remains permanent, very much as happens when an ear is pierced for an earring. An articulated hand is now applied to the limb, the catgut tendons representing the extensor tendons being hooked through the extensor loop, and the flexor through the flexor loop or loops. It is claimed that the patient soon learns to move the fingers by drawing upon the loops by means of contraction of the muscles concerned.

The limb which has been found most generally useful for forearm amputations at Erskine is the *Williams*. It is slipped on by the patient himself almost as easily as a glove, and is secured by lacing of the soft leather above the elbow. It is very strong; the patient can do any amount of hard work with it, without fear of spoiling it, or of its coming off when he is pulling with it, but it does slightly limit flexion at the elbow, and also pronation and supination.

It is generally supplied with an ornamental hand, and a hook for working. The hook swivels, and is fitted with a strong spring, so that it yields slightly on traction or on application of lateral pressure.

The hook can be replaced by numerous tools, but the change is slow on account of the screw catch.

The *U.V.F. fitting* obviates this difficulty. The various tools are fitted with a tube handle which slides within another tube in the socket of the artificial limb, and locks at any angle. A tool can therefore be fitted instantly, and, when done with, it falls out on releasing the spring, and another can be inserted.

The U.V.F. fitting is not quite perfect as yet, but is being improved, and is fitted to the Williams arm. The *M'Kay arm* differs from the Williams in several particulars. The forearm is composed of duralumin instead of leather, and is held in position by straps running up to a leather sleeve on the upper arm. This arrangement permits of

(1) Gauntlet for disarticulation at wrist.

(2) William's arm.

(3) Erskine type for amputation of forearm permitting greater flexion at elbow.

(4) Erskine type for amputation of upper arm.

rather more free movement at the elbow, but is not equally firm, and is not suitable for short forearm stumps, which tend to draw out of the socket. The hand, composed of wood and rubber, has an articulated thumb, closed by a strong spring, and opened by a catgut tendon worked from the opposite shoulder. The fingers are composed of rubber with a stout copper wire up the centre of each, and can be moulded into position by pressure of the sound hand, while they are sufficiently stiff to maintain their position when in use, as in carrying a bag. The copper wires can be readily renewed. Hand, hook, and various tools are supplied with a fitting which is strong and permits of immediate attachment or detachment, and adjustment to any angle of rotation. It consists essentially of male and female cogged wheels which slide upon one another until when fully engaged they are locked by a spring at the top. As the teeth of the wheels are absolutely true, any tooth will fit any slot, and so any angle is obtainable.

In *amputations close to the elbow* the fragment of forearm has little or no power of pronation and supination, and it is not easy to fit a bucket which will prevent the short stump coming out on flexion. The Williams arm, however, overcomes this difficulty extremely well, and it is a great matter for the patient to possess the power of voluntary flexion, even if limited, while, even without an artificial limb, he may be able to catch and lift things in the crook of the elbow.

The rule, therefore, in approaching the elbow, is to *save every available portion of bone.* Even if there be scarcity of skin this may be overcome later by use of whole skin grafts.

Amputation in the upper half of the forearm may be performed in the same manner as in the lower half, save that modified circular flaps are generally necessary. In all cases where there is plenty of skin be sure that the skin-flaps are abundant. Unless experienced in amputating make them on the modified circular plan—a circle

with two lateral cuts upwards, the length of the lateral cuts being about the diameter of the arm in length. Flaps of unequal length should be employed wherever the skin on one surface has been unduly damaged.

Disarticulation through the elbow is undesirable for the same reason that disarticulation at the wrist is—it does not leave room for mechanism and the end of the stump is bulbous. Still, the difficulty can be overcome by making the artificial forearm shorter.

The **seat of election** is about two inches **above the elbow joint**. The amputation may again be performed with

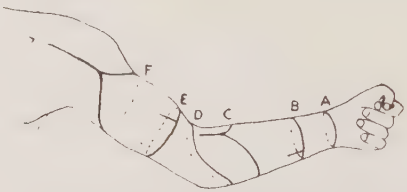


Fig. 55.—Amputations of upper extremity.
D Oblique ellipse for above elbow. E Modified circular for lower humerus. F Racket for disarticulation of humerus.

circular incision through the skin, but the incision is best made elliptical and directed downwards toward the fingers posteriorly so as to preserve the skin over the olecranon, which is particularly suitable for sustaining pressure.

As in these cases the patient has lost the power of the elbow movement, this has to be furnished by the artificial limb, and further, as the elbow is gone, the limb cannot be fixed in the simple manner employed by Williams.

The arms chiefly used in the *above elbow cases* at Erskine consist of a forearm with detachable hand, hook etc., with an articulation at the elbow worked by means of a Bowden wire from the opposite shoulder. Various forms of joint are employed, and they are generally fitted with a locking mechanism which can be put into or out of gear by the patient by means of a projecting stud which he

(1) U.V.F. fittings.
(2) M'Kay arm (suspended by its shoulder straps).

can move through the sleeve of the coat. When the lock is undone the arm swings naturally as in walking; when in gear it locks at whatever position of flexion patient desires (by means of the other shoulder action) and it can again be unlocked by a quick jerk of the opposite shoulder, when the arm falls once more into the extended position.

The forearm and elbow are held in position by means of a socket or broad girdle of leather fitted to the upper arm stump, which again is prevented from slipping by straps running up to the shoulder.

In some cases the elbow is not worked by a Bowden wire but the forearm is thrown up by a swinging motion and automatically locked. A moveable thumb or moveable opening hook clasp may similarly be actuated by a Bowden wire from the opposite shoulder, or from a loop worked by the sound hand in the trouser pocket.

As movements obtained from the opposite shoulder generally involve an opposition movement of the affected limb and hand, whereby delicacy of movement is destroyed, and the movement obtained thereby is not very powerful, experiments are being prosecuted at Erskine at present with a view to obtaining the motive power from some other part of the body, such as the lower limb, foot and toes, and from motors.

Once these experiments are successfully completed it is hoped to supply a patient with an amputation above elbow with a thumb and finger and an elbow both of which will be easily moveable at will.

Naturally the further up on the upper arm the amputation is, the less is the power of the limb. If *above the insertion of the deltoid* the power of abduction is greatly diminished, and the patient often possesses remarkably little control of the stump.

This want of control is probably due in some instances to the muscle-flaps not having been stitched over the end of the cut bone, whereby the end of the bone is exposed and likely to become adherent to the skin

while the muscles contract and retract and lose their power.

Although an amputation close to the shoulder provides a stump with but little power of movement, it is preferable to a disarticulation, in which the head of the bone is removed and the contour of the shoulder destroyed.

In *amputating the upper arm above the seat of election*, the method chosen should generally be that which will enable the maximum length of bone to be saved. The circular or modified circular method is generally the most economical except where the tissues have been more extensively damaged on one surface than another, when an elliptical incision is to be preferred.

In the circular method the skin incision is made about the length of the diameter of the limb below the point of section of the bone. In cutting the muscle-flaps, the biceps retracts freely compared with brachialis anticus and triceps which are attached to the bone. The musculo-spiral nerve should be raised from its groove and cut short before the bone is divided. Care should be taken to stitch the muscle-flaps carefully over the end of the bone, particularly such as contain the biceps and deltoid which tend to retract freely.

In *amputations near the shoulder*, and indeed in most amputations much above the elbow, it is found best to obtain support for the artificial limb from the trunk by means of a half vest, generally composed of leather, moulded to fit the shoulder and side, and held in position by straps to the opposite side. The stump fits in to a bucket, also generally of leather, attached to the vest by straps, to the lower end of which is fitted the artificial elbow joint. The artificial forearm may be of leather or metal, and is flexed by means of a Bowden wire from the opposite shoulder, or otherwise.

Disarticulation at the shoulder should not be performed for injury, unless the joint is already involved and the condition of parts hopeless. It may be necessary in certain diseases such as sarcoma of the shoulder, when,

however, the scapula may also require removal. Disarticulation may be performed with a *deltoid flap* by commencing the racket-shaped incision above and to the outer side of the tip of the coracoid, the knife going right down into the joint. The incision then runs down the bicipital groove, the limb being meantime rotated outwards and the clavicular fibres of the deltoid and pectoralis major are divided, until on reaching the level of the insertion of the deltoid it runs outwards and then backwards. Up to this stage the incision is carried down to bone, but as it is now finished by running round the inner side of the arm to meet the vertical portion it is made skin deep only. The vertical incision is now retracted and the bone exposed. The head is disarticulated, and the muscles cut or shelled from the bone. The vessels should then be exposed and ligatured before being cut; the nerves are cut short, and the disarticulation completed.

If in a case of injury some fragments of bone can be preserved it may be possible to fashion a stump which will be of service to the patient.

In cases of disarticulation an *arm with moveable shoulder and elbow* is provided, the arm being held in position by means of a leather vest as already described. In most cases the limb has only an aesthetic value, masking the deformity of the shoulder, and providing a swinging arm and hand, but if the shoulder-joint be provided with a lock, it is possible to fit a moveable elbow worked from the other shoulder by a Bowden wire and fixed in various positions by an automatic lock. Most men prefer a very light and purely aesthetic arm in these cases.

Amputations of the Lower Extremity.

In lesser injuries of the foot, an endeavour should be made where possible to save the great toe, as much of the spring of the step in walking depends upon its presence. Two amputations deserve special consideration—Lisfranc and Syme.

Where the injury is confined to the anterior part of the foot, and sufficient skin-flap is available, **Lisfranc's**

Fig. 56.
Amputations of Toes.

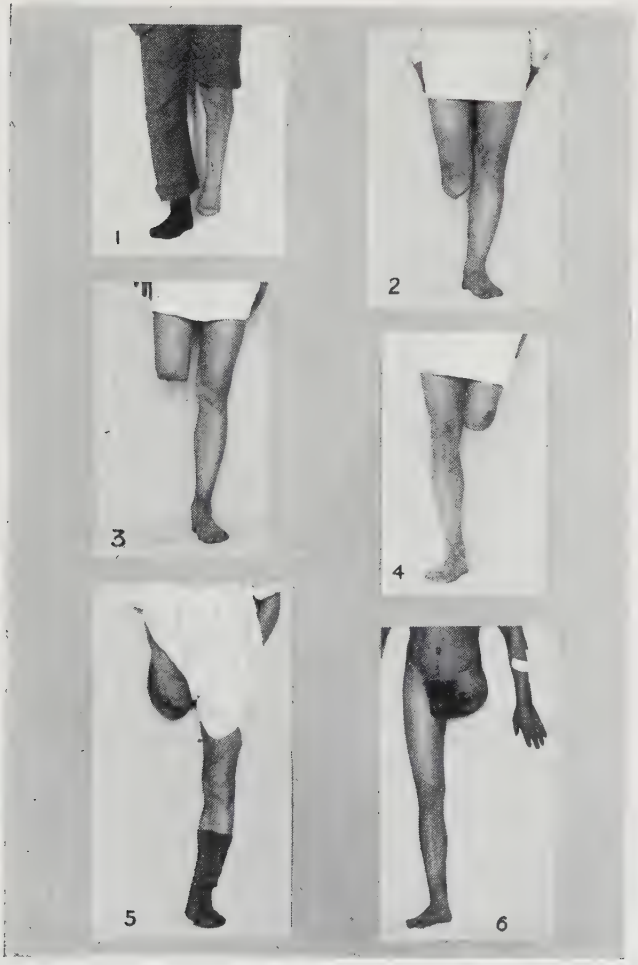
amputation is an excellent one. The writer has performed the operation chiefly on children suffering from tubercle

Fig. 57.
Lines of skin incisions and of disarticulation in a Lisfranc.

of the metatarsus, and the results have been excellent, the children running about actively, barefoot, without any apparatus. His experience is that the directions

(1) Erskine arm for amputation in upper arm.

(2) „ „ „ disarticulation at shoulder.



TYPES OF AMPUTATION OF LOWER EXTREMITY.

(1) Syme.
(2) "Seat of election" below knee.
(3) and (4) Good, above knee, amputations.
(5) Short stump with large puckered cicatrix. Would require a pelvic band
(6) Disarticulation with large puckered cicatrix.

given do not provide sufficient flap, and there is consequently dissatisfaction with the results obtained, a midtarsal disarticulation having frequently to be performed in order to get the flaps to meet. The method employed is as follows :—

Define the bases of the first and fifth metatarsals respectively, and make an incision down to the bone extending from the base of the first, on the inner side of the foot, to the root of the great toe. Then run across the foot, keeping close to the roots of the toes all the way to the little toe, and then run the incision back along the outer border of the foot to the base of the fifth metatarsal. The flap so marked out is now reflected, all the tissues being included in it right down to the bones, which should be exposed up to their bases. The dorsal flap is next cut by a curved incision running from about the centre of the longitudinal incision on the inner side, to a similar point on that on the outer, and is also deflected, taking up all the structures down to the bone.

The bones are next disarticulated, beginning generally with the " coup de maître " at the joint of the second metatarsal, which is not on a level with the other joints but slightly higher up. The opening of this joint is much assisted by strong flexion of the foot. The other joints are easily found and opened, and the metatarsus removed. *Skey* saws across the base of the second metatarsal instead of disarticulating, and *Cooper* saws across the bases of all, thereby preserving the tendon insertions of the peronei and tibialis anticus. *Hey*, instead of disarticulating the first metatarsal, saws through the internal cuneiform at the level of the articulation between the second metatarsal and middle cuneiform, and this precedure may be adopted where the flap is found to be rather short on the inner side. No large vessel is cut, except the dorsalis pedis on the dorsal flap.

After this amputation all that is required is a little padding in the toe of an ordinary boot to prevent the foot slipping forward.

Where the extent of the damage prevents a Lisfranc being performed a *Chopart* may be substituted. The flaps are cut as for a Lisfranc, but the flap from the sole commences at the tuberosity of the scaphoid and extends forwards to beyond the middle of the first metatarsal. It then crosses the sole, and runs backwards to end at a point opposite to that at which it began. In the standard operation the disarticulation is performed

Fig. 58.
Lines of skin incision and of disarticulation in a Chopart.

between the astragalus and scaphoid on the inner side and the os calcis and cuboid on the outer, but a good result may be obtained by sawing the bones either proximal or distal to these joints. The extensor tendons should be carefully sutured to the periosteum of the bones before stitching the flaps.

Great care is required in the subsequent treatment to keep the foot at right angles to the leg, so as to prevent contraction of the tendo Achillis, which otherwise almost invariably occurs.

In successful cases the patient can frequently walk without special apparatus. A boot with padding in

the anterior part to prevent slipping forwards of the foot may be sufficient, but sometimes a boot with a long leg is necessary and it may be necessary to stiffen the sole.

In many cases the tendo Achillis contracts and the stump of the foot becomes pointed, necessitating tenotomy or lengthening of the tendon, and sometimes, in long standing cases, where changes in the articular facets have occurred, reamputation.

Syme's amputation is an excellent one: the stump is capable of bearing the whole weight of the body and

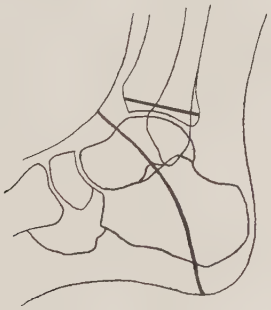


Fig. 59.
Lines of skin incision and of saw cut in Syme's amputation.

a higher amputation should never be performed where there is a possibility of performing a Syme. The writer has often gone through damaged tissues, deliberately, in order to secure a Syme, and the results have been almost invariably successful. In cases where sepsis is very considerable he delays stitching the heel flap until it has been controlled. Where the sepsis is less the flap may be held in position by a few silkworm sutures, and packing inserted.

The method is as follows :—

Define the tip of the external malleolus and take a point just in front of it and another, opposite the first, on the inner side. With the foot strongly dorsi-flexed make a vertical incision beginning at the external point,

down, across the heel, and vertically up to the corresponding point on the inner side. The incision is made down to the bone and should cross the os calcis *behind* the ridge of its posterior tuberosity. The flap is now carefully dissected up from the bone so as to include all soft tissues and not damage the posterior tibial vessels. When the tendo Achillis is exposed posteriorly it may be peeled off from its origin or divided close to it.

The skin incision is now completed by joining the ends of the first incision by one running across the dorsum—the completed incision is practically an ellipse. As the dorsal incision is deepened the joint between tibia and astragalus is opened, the foot now being strongly flexed, and the astragalus is disarticulated, care being taken not to damage the posterior flap as the disarticulation is completed.

The ends of tibia and fibula are next exposed and cut off level just above the malleoli. The dorsalis pedis, plantar arteries and smaller branches require ligature. The cut ends of the bones are padded with iodoform and boracic powder, and the flap is then turned into position and stitched.

Where dressing is required care should always be exercised in removing the old dressing to take it from below upwards, so as not to pull the heel-flap away from the bones, and it is also a good plan to provide a board at the end of the bed and encourage the patient to press the stump regularly and firmly against this. As soon as the wound is healed, the stump should be regularly patted firmly with the palm of the hand, and this patting should gradually increase in force until the patient can stand very firm pressure without inconvenience. This treatment should be carried out regularly in all amputations of the lower limb as it has a marked effect in rendering the end of the stump less tender, and capable of bearing weight without inconvenience.

It has been argued in favour of *Pirogoff's amputation* in which a portion of the os calcis is preserved in the

(1) and (3) Erskine fittings for Syme's amputations.
(2) Os calcis drawn up posteriorly in a Chopart.
(4) Double Chopart with slight tendency toward pointing, which was overcome.

heel flap, that the two limbs are of the same length whereas in Syme's amputation the limb is shorter. But this shortening is of advantage as it leaves room for the introduction of mechanism to give the necessary spring in walking.

The *apparatus used* consists of an artificial foot with a joint at the ankle communicating with an attachment for the leg by which it is kept in position. In this case the patient bears all the weight on the end of his stump which rests on some form of elastic pad from which the necessary spring is derived. The advantages of such an 'end bearing' are considerable, but once the limb is amputated higher up, end bearing of the entire weight becomes impossible, and in many cases the patient is unable to take any weight on the end of the stump. It is usual therefore in other below knee amputations to arrange for most of the weight to be borne by the tubercle and tuberosities of the tibia and head of the fibula, the bucket of the limb being carefully moulded to shape. A little weight may be taken by the sides of the bucket, but as a rule such fitting has a tendency to drag up the skin so as to cause pressure and possibly sores on the apex of the stump. A slight end bearing may be taken by a good sound stump resting on an 'ablutonic' rubber sponge, or pad of special spongy rubber.

In addition to or instead of bearing the weight on the upper end of the tibia the limb may be prolonged up so that patient will rest his tuber ischii upon it as in above knee amputations.

Where a Syme is impossible the amputation of the leg should be performed as low down as possible, as the longer the stump the greater the leverage.

One of the difficulties in **amputations of the leg** is the sharp subcutaneous crest of the tibia which tends to project into and damage the skin of the flap. As it is almost impossible to cover the tibial crest with muscle, various devices are used to overcome the projection. The simplest is to bevel off the projecting end of the bone,

the periosteum having first been deflected, after which the periosteal flap is turned down over the cut surface of the bone. An osteo-plastic flap of tibia may also be cut and used as a covering as described later.

Whatever form of amputation is selected care should be taken to keep any vertical incision well away from the crest of the tibia. As a rule the fibula is divided rather higher up than the tibia.

Teale's amputation with a very long anterior flap is a good one, but necessitates the removal of an undue amount of bone. It could only be recommended where the injury to the back of the leg and bones was much more extensive than that in front.

The anterior flap is half the circumference of the leg at the point of section of the bones both in breadth and length. The posterior flap is one quarter the length of the anterior.

Both flaps include all the soft tissues down to the bones and interosseous membrane. After the bones have been divided the long anterior flap is turned on itself, so that its cut extremity is directed upwards to meet the short posterior flap to which it is sutured.

Amputation may be performed by unequal flaps, the long flap being cut from either the anterior or posterior aspect, and being fully the diameter of the limb, at point of bone section, in length, while the short flap is half the length of the long one.

An *elliptical incision* is probably as good as any, and the ellipse may be inclined to suit the circumstances of the case.

Where suitable the ellipse may be cut with the flap on the *antero-external* surface. The incision is made down to the muscles, and is then allowed to retract fully. The muscles are next cut at the level to which the skin has retracted, and they are allowed to retract fully, after which the bones are divided at the highest point of retraction. This operation has the advantage of economy of tissue, and it can also be planned to take

advantage of an *osteoplastic bone flap from the tibia*. The skin does not readily retract from the subcutaneous surface of the tibia, and it is not made to do so above the point of section of the muscles.

FIG. 60—Amputations of lower extremity.
In order from below upwards
Teale.
Ellipse.
Faraboeuf.
Stokes gritti.
Unequal flaps.
Disarticulation by racket.

By means of a Gigli saw a thin flap of tibia is now cut from its subcutaneous surface, without disturbing its connections with the skin, and finally the skin-flap with the piece of bone in position is turned up and the tibia divided obliquely slightly above the position of the upper end of the flap of bone removed.

The anterior tibial vessels on the interosseous membrane ; the posterior tibials between superficial and deep muscles, and the peroneal vessels behind the fibula are ligatured ; the large nerves are pulled down and cut short, and a few sutures of catgut may be used to unite the anterior and posterior muscles. The skin, with the piece of bone in position is then brought down ; the bone-flap fitted accurately over the cut end of the tibia, and, if necessary, pinned or pegged in position and then the wound is sutured.

As the knee-joint is approached every care should be taken to save as much of the tibia as possible. In the old days the *seat of election* was defined as a hand-breadth below the knee, because then kneeling buckets were used in conjunction with a pin leg. At the present time this seat of election is not the most suitable for an amputation. It is too short to actuate an artificial leg well, and the stump tends to come out of the bucket. On the other hand it is too long to permit of the fitting of a neat modern limb with kneeling attachment.

Amputations about the upper third may be performed by one of the methods already described, or Faraboeuf's method may be employed. It is frequently an advantage to disarticulate the fibula and remove it entirely in the higher amputations of the leg.

Faraboeuf's amputation is performed by means of a large antero-external flap. The incision runs vertically down along the inner border of the tibia, and then sweeps across the front of the leg to the outer side and round to the back, where it curves up to run vertically in the middle line to a point one and a half inches below the level of the point of origin. The length of the large U-shaped flap is fully the diameter of the limb at the point of section, and it includes everything down to the bone and interosseous membrane, the anterior tibial artery being cut close to the end of the flap.

The posterior incision runs horizontally from the posterior end of the U to meet the anterior limb of the

(1) Limb for amputation below knee (long stump).
(2) Another type with eccentric knee joints for shorter stump.
(3) Same, where amputation close to knee as in "seat of election" with "slip" of leather.
(4) Same, where amputation very close to knee, with "kneeling bucket."

U one and a half inches below its origin. The fibula may be disarticulated, and the scar lies on the inner side.

The artificial limb for amputations below the knee consists of a wooden bucket which contains the stump, and which extends up to and is moulded to fit the tubercle and tuberosities of the tibia and head of fibula. Individual tastes differ as to the exact point at which the bucket should end, and much of the comfort of the limb depends upon the point of termination and the accurate moulding of this upper end, so that the weight is evenly distributed over a considerable area. Most men like it to end on a level with the end of the tibia when the limb is straight. In all cases it should keep well clear of the tip of the patella. The weight is chiefly borne at the upper end, and some find a "*slip*" of leather let in at this point an additional comfort. The slip of leather is of great use where a "seat of election" stump has to be fitted. It materially assists in keeping the stump in the bucket.

The bucket is held in position by steels extending up the thigh and jointed at the knee. If these joints, instead of being in the line of the steels, are displaced backwards by curving of the steels so that they are "eccentric" the movements are greatly facilitated and the stump has less tendency to come out of the bucket. The steels are fixed to a leather casing which embraces the thigh and which is held in position by lacing.

The foot is attached by a simple ankle-joint, behind which a spiral spring is inserted. The foot is of wood and leather, the front portion being capable of slight dorsi-flexion on pressure.

The thigh casing may if necessary be extended upwards so that the patient will bear all or part of his weight on the tuber ischii.

When the *amputation cannot be performed at or below the seat of election*, the portion of tibia should be cut very short, so that when the knee is flexed to a right angle it does not project behind the posterior surface of the

thigh. An elliptical skin incision, with the long skin-flap in front, does very well here.

After the operation is finished the knee should be put up flexed, and care must be taken to prevent the knee from becoming rigidly extended, as the patient walks with the knee flexed, taking a very considerable portion of the weight on the knee.

The *artificial limb employed* is somewhat similar to that described for amputation lower down, but the thigh-piece is much more substantial, and while of leather and fixed by lacing, it extends to the tuber ischii above, while below it is moulded to the bent knee.

In amputations of the lower limb, and particularly those above the knee, it is important not to allow the patient to acquire the *crutch habit*, as, once formed, it is difficult to eradicate and prevents the patient from walking as well as he otherwise would do. While crutches are used the muscles atrophy and the nerves and centres in cord and brain controlling the movements of the limb also suffer so that much effort and practice is subsequently necessary to regain control. As soon, therefore, as the wound is healed, even if there be a persistent sinus, the patient should be provided with a provisional limb.

The **Erskine provisional limb,** designed by Sir William Macewen, has been so successful, that not only do most men succeed in walking with one immediately but, in many cases, owing to its extreme lightness and simplicity, they prefer it to the more elaborate limb. For amputations above the knee it consists of a pelvic ring of wood, of special design, made in various sizes, which provides the necessary resting-place for the tuber ischii without exerting pressure on the perineum. This ring is supported by thin wooden struts leading to a thick disc of wood, of narrow diameter, situated a short distance above the position of the knee. Between the ring and the disc a bucket is formed of three-ply wood, which is thin and adjustable to various diameters of limb by means of straps and buckles.

TYPES OF PEG LEG.

(1) For below knee amputation where part of weight is taken by tuber ischii.

(3) Ditto where whole weight borne by stump.

(2) Most complete form for thigh amputation with pelvic ring, adjustable bucket, knee-joint with lock, and foot with moveable ankle.

In its simplest form a stout broomstick is fixed by means of a screw to the disc of wood, and has a rubber tip, such as is used in crutches, at the lower end. In the more elaborate forms a simple knee-joint with lock is provided, and also a simple foot. A shallow cup at lower end of bucket to give an end bearing may also be fitted and is adjustable by means of a screw so as to take more or less pressure. When a patient can tolerate an end bearing it is of great advantage to him as it helps considerably in controlling and directing the movement of the limb.

These limbs can be fitted in fifteen minutes to any size of limb and patient, and they are cheap. As the bucket is adjustable the patient can wear it with comfort while the stump is moulding, and becoming thinner or thicker, or growing as in children.

Peg legs for below knee amputations are still more simple, but are frequently extended so as to take a bearing from the tuber ischii when the patient cannot take an end bearing.

It is probable that limbs on the principle of the Erskine peg leg will ultimately supplant the more elaborate types. They are comparatively cheap ; are easily and rapidly fitted ; are light and easily worked and repaired. Many men prefer them, particularly when working. The writer would commend them specially to the attention of the profession. A description and specification to which a tradesman can work is issued by the Erskine Research Laboratory and a good serviceable limb can be quickly constructed therefrom at little cost. The more elaborate types with moveable knee-joint and foot cost the Hospital, at present high rates for material and wages about £3. With such a limb an ordinary boot can be worn and when the patient walks well it may be very difficult even for an expert to say what is wrong. It should be remembered however that some men actually prefer the simple type with stiff pin and rubber tip.

Disarticulation at the knee supplies an excellent stump, with a broad end which bears pressure well, and powerful

movement, but it does not form a satisfactory amputation for several reasons. In the first place, although it bears pressure well at first, it often becomes tender after a time, so that several men who were thoroughly satisfied at first have returned to Erskine later asking to have an amputation higher up. In the second place the mechanism of the artificial knee must project beyond the position of the normal knee, and, in the third place the bulbous extremity of the limb caused by the broad condyles will not slip down into a bucket cut to fit the limb higher up, particularly if that upper portion has atrophied. For

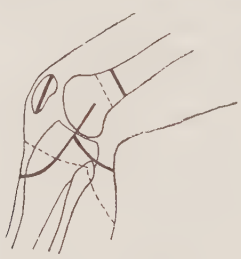


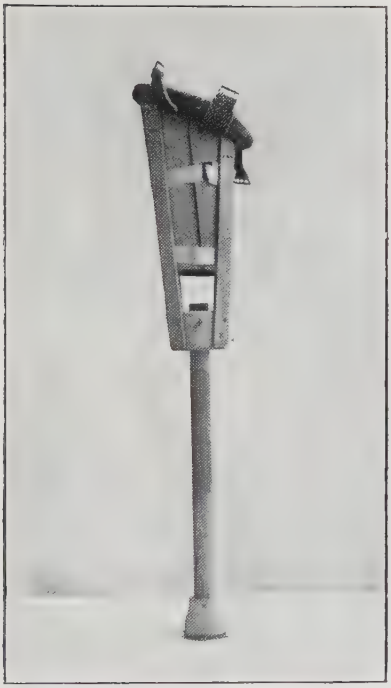
Fig. 61.

Black lines are those of skin incision and saw cut in a Stokes Gritti. Dotted lines are those of a Lister modification of Carden.

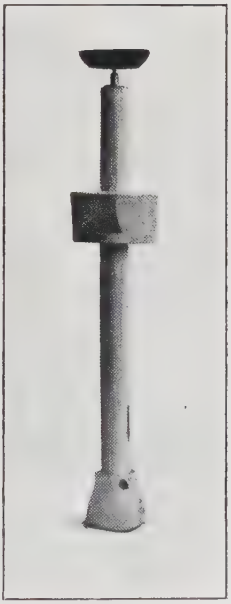
these various reasons, therefore, an amputation above the condyles is preferred.

A **Stokes Gritti** or similar operation may be performed. The operation is performed by a long anterior U-shaped flap extending from the prominences of the condyles above to the insertion of the ligamentum patellae below, and a short posterior flap, half the length of the anterior. The knee is flexed, the ligamentum patellae divided, and the joint opened. The muscles are cut at the level of retraction of the posterior skin-flap, and the leg removed. The femur is divided an inch above the condyles, and, if desired, the articular surface of the patella may be removed, and the cut surface applied to that of the femur, and fixed later by a pin inserted through the skin.

PLATE XXXVII



Erskine provisional limb in simplest form. Adjustable bucket.



Peg with disc of wood, adjustable shallow cup, and rubber tip.

The popliteal and articular vessels are ligatured, the nerves cut short, and the flaps stitched. Where the patella is retained and fixed to the femur it is often an advantage to slightly bevel the cut through the femur from above downwards and backwards.

Where the amount of tissue permits, a *Lister modification of Carden's* amputation may be performed. A horizontal incision is made across the front of the leg, down to the bone, at the level of the tibial tubercle, the incision occupying the anterior half of the circumference of the limb. From its ends a posterior flap is cut extending downwards from it at an angle of forty-five degrees. The flap may be cut by transfixation, or the skin may be cut and allowed to retract, and then the muscles divided at the level of retraction. The patella is removed; the femur divided above the condyles, the vessels ligatured, and the flaps united.

Amputations through the thigh should be performed as low down as possible, and the beginner should ever bear in mind that every inch makes a difference in the capacity of the limb. As the flaps must be sufficiently long to cover the end of the bone without tension, the point of section of the bone is often determined by the amount of sound skin available, and it is generally desirable to determine the form which the skin-flaps should take so as to make full use of this skin. It is also important to make good muscle-flaps, which are stitched over the end of the bone, thereby increasing their power and preventing the possibility of an *adherent cicatrix*, in which the scar in the skin is adherent to the bone and is a constant source of trouble. It is generally tender, frequently breaks down, and often necessitates re-amputation. Muscles such as the adductors and extensors, whose fibres are oblique, and with extensive attachment to bone, retract less than others such as the hamstrings with straight fibres and freedom from bone attachments, and when the limb is raised from the table the muscular mass gravitates to the back of the thigh. These points

require to be borne in mind when arranging the incisions, and it is also advisable when so doing to make sure that a longitudinal incision does not run in or near the line of the vessels, which should occupy the posterior flap when the amputation is below the middle of the thigh.

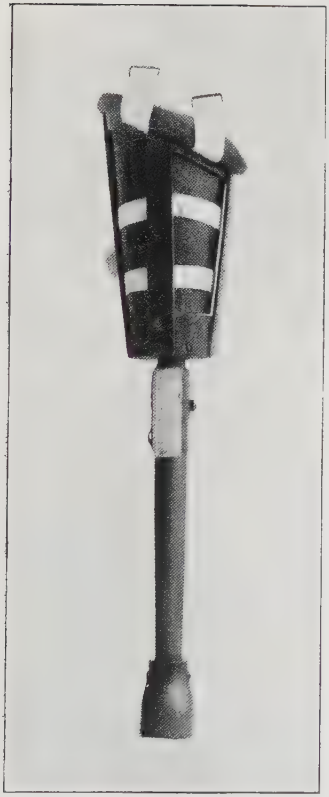
If unequal flaps are employed a long U-shaped anterior flap, half the circumference in breadth and fully the diameter in length, and a short posterior flap, fully half the length of the anterior should first be cut down to the muscles. They should then be raised from the underlying muscles for about an inch, care being taken in so doing not to injure the panniculus adiposus and damage the circulation in the flaps. The muscles are then cut by a series of circular sweeps of the knife, the flaps being steadily retracted as this is done, and allowance made for the unequal retraction of various groups as already described. When the bone is exposed the periosteum is reflected to beyond the point of section; it is sawn across, and the end dabbed with iodoform and boracic powder. The main vessels and branches of the profunda, obturator and sciatic vessels are ligatured; and the sciatic nerve cut short. When completed the amputation should have the arrangement of an inverted cone, the skin forming the base and the bone the apex. The periosteum is stitched across the cut end of the bone.

The muscles are now carefully brought together and sutured, including any which may have unduly retracted, the cut end of the bone being covered by them, and then the skin is stitched.

In all cases care must be taken to avoid a bulbous extremity to the stump as such a form cannot go into a properly fitting bucket.

In amputations of the thigh the weight is not borne by the end of the stump nor by the pressure of the stump against the sides of the bucket, at least to any extent. *The weight is borne by the tuber ischii* which practically sits upon the upper end of the bucket. It does not follow from this, however, that the shape of the bucket

PLATE XXXVIII.



Erskine Provisional Limb with pelvic ring, adjustable bucket, simple knee joint and rubber tip.

Elaborate form of provisional limb with standard knee joint and foot. Adjustable bucket.

is immaterial. In the first place the upper end must be so shaped that the tuber rests comfortably upon it, while it *does not press upon the perineum.* In the second place, if the tuber is to rest upon the proper spot, the bucket must be neither too small—in which case the tuber would not come down to its proper position and the weight would be borne on other parts—nor too large, in which case the tuber may slide within the bucket, with a similarly unsatisfactory result. In the third place, while the weight is borne by the tuber, the movement is imparted by the stump, and if it be cramped, or if it has room to move about inside, pressure or friction sores will readily develop, just as in an ill-fitting boot. Still further, when the tuber does not come properly into position, the skin of the thigh is dragged upon by the sides of the bucket, and thus a stretching of the tissues at the end of the stump occurs, with, possibly, the opening of a weak cicatrix.

In the *Erskine pattern of limb* the bucket is composed of Scotch willow, specially dried by warm air-current, and cut by pattern makers to shape by means of templates. The writer has devised a machine somewhat on the principle of the statue copying machine, which, by means of a revolving cutter, resembling a surgical bone bur, cuts out the bucket from a cast of the limb. The bucket is thus made in a very short time and fits like a glove. Stumps frequently atrophy after fitting, and the patient requires then to wear one or more stump socks in order to make the fit sufficiently firm; but curiously, some limbs hypertrophy or become fat after fitting, necessitating recutting or renewing of the bucket.

The bucket is held in position by means of straps over the shoulders. It is fitted with a moveable knee with spring, and also with a lock, so that the limb may be rendered stiff when walking over rough or hilly ground. The ankle and foot are similar to those supplied for below knee amputations. The weight of this limb, covered with leather, and with fittings as described but without

straps, does not exceed six pounds, and has been brought as low as four and a half pounds in special cases. Army pensioners regularly report that they are on their feet all day wearing the limb daily from morning till night, some of them occasionally walking seven to fifteen miles at a stretch.

Where a patient finds that his skin is pulled up when slipping on a closely fitting bucket he should first pull on a thin stump sock, then slip the limb into position and finally bring the end of the sock through one of the holes at the knee-end of the bucket and so pull the sock off. This brings the skin well into position and prevents dragging on a weak cicatrix.

When the length of femur is five inches or less measured from the fork (equivalent to about seven inches from great trochanter) the stump has a tendency to abduct, and the patient has less control over his limb, necessitating the provision of a steel *pelvic band*. This band, not more than one and an eighth inch wide and one sixteenth inch thick, and padded, encircles the pelvis above the great trochanters and below the iliac crests, and is attached to the upper end of the bucket by a jointed steel strap. It adds to the weight (total of seven to eight pounds), and renders the limb slightly less flexible, and should therefore only be employed where necessary, but it is an essential where the amputation is high up.

When amputation is called for in the region of the lesser trochanter, the question arises as to whether it is better to do such an amputation or to disarticulate. The retention of the bone does add to the power of the stump, but it is very difficult to construct a limb which will retain the stump in the bucket when the patient sits. In some such cases the difficulty has been got over by giving the patient a disarticulation fitting, and he has walked fairly well with it, but it is questionable if a patient with a disarticulation does not walk fully as well, and feel more comfortable. Even a disarticulation stump has very considerable power of

(1) For above knee with leather bucket moulded at lower end to take a bulbous stump and laced up.

(2) Standard thigh amputation limb with bucket of Scotch willow.

(3) Ditto with pelvic band for short thigh (5 in. from fork or less).

(4) Ditto applied.

Two views of limb for disarticulation at hip. This type may also be used for amputation very high up. Pelvic band is seen above.

movement if the muscles are carefully united before stitching the skin-flaps.

In amputations close to the lesser trochanter, or in disarticulation, the limb should first be emptied of blood by elevation and the application of an elastic bandage from below upwards. A tourniquet should not be employed to control haemorrhage, as it is apt to slip, but the aorta may be compressed by an assistant who, standing on a stool at the side of the table, leans his weight through his arm, which is kept straight, and his shut fist, on the patient's abdomen, a little to the left of and below the umbilicus.

The operation for high amputation may be done by a *racket incision*, and if the operator is short-handed he may make the handle of the racket in the line of the femoral artery and tie it at once, or, better, he may make a small preliminary incision across the artery and vein and tie them before proceeding to the amputation proper.

If he elects to tie the artery in the line of incision, he makes a vertical incision over the line of the vessel to as low a point as healthy skin will permit, or fully the diameter of the limb, and then encircles the limb, the incision extending down to the muscles. The artery and vein are then exposed at the upper end of the incision and ligatured separately, after which the muscles are divided by a series of circular sweeps of the knife, the bone exposed, and sawn across. Some advise that the sciatic and anterior crural nerves should be "blocked" by an injection of novocain before they are divided, but in any case they should be cut short. The smaller vessels such as obturator and gluteal are ligatured, and then the muscle masses are carefully stitched together over the end of the bone, which is padded with iodoform and boracic powder as usual, and then the skin is sutured.

Disarticulation may be performed through a similar incision, the joint being exposed from the front after division of the muscles in that region, or as follows :— A racket is described with the handle beginning well

above the tip of the great trochanter and running vertically down the limb for fully six inches and cut down to the bone. Then an elliptical sweep is made with the apex preferably on the inner side, the incision going down to muscle only, after which the skin is retracted and the muscles divided down to the bone by a series of circular sweeps. The muscles are now cleared from the hip by section and retraction through the vertical incision and the joint exposed and opened. This is most readily done from the front, and the head is then forced out by an assistant adducting and rotating outwards, and the ligamentum teres divided. The rest of the capsule is now divided, the muscles stripped from their insertions into the bone, and the bone removed.

The vessels are next ligatured, the nerves cut short, the muscular masses sutured together and the skin-flaps stitched.

In disarticulation at the hip the patient is provided with a *shallow bucket for reception of the limb stump*, kept in position by means of a pelvic band and straps over the shoulders. An artificial hip-joint is provided, and in other respects the limb is similar to that supplied in amputations of the thigh.

In many cases patients adapt themselves very rapidly to a disarticulation limb, walking well when others with amputation about the middle of the thigh are still in difficulty.

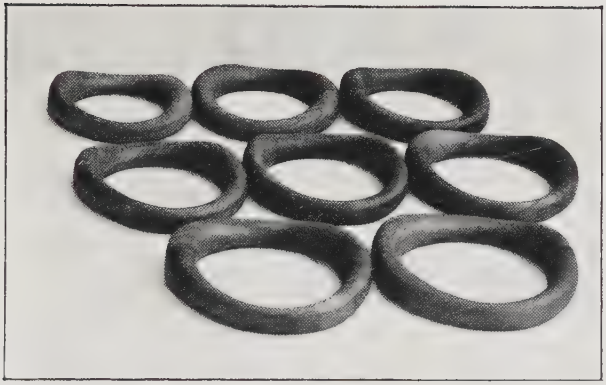
Patients with *double amputation of the lower limbs* frequently walk well if the amputations be below the knee. Naturally they require a longer time to practise, and at Erskine gangways with a railing at either side are provided upon which they may practise, while supporting themselves by the handrails.

In some cases of double amputation below the knee the patients not only walk well ultimately, sometimes without a stick, but can keep their limbs on all day and walk comparatively long distances—one pensioner reported recently that he could walk seven miles at a stretch.

Double amputation of leg below knee. Patient has chosen a kneeling bucket limb on right (had slip socket limb supplied later) and regular limb for left.

APPENDIX

COMPENSATION FOR INJURIES



Erskine pelvic rings.

Dissected limb showing latest type of foot and knee. Note eccentric joints at knee.

APPENDIX

Compensation for Injuries.

The Workmen's Compensation Act (1906) in this country does not provide a scale of payments for various injuries. Where an agreement cannot be come to between employer and employee the matter is referable to the Sheriff who decides the amount due after hearing evidence on both sides. Where medical evidence is led he may be assisted by a Medical Referee appointed under the Act.

The Act provides that the amount of compensation, in cases of total or partial incapacity for work, shall be a weekly payment not exceeding the workman's average weekly earnings during the previous twelve months, such weekly payment not to exceed £1. The Act also contains provisions as to redemption of weekly payments by a lump sum. Where the injury is permanent, after a period of not less than six months, and on application by the employer, a lump sum may be substituted for the weekly payment, which, invested under the National Debt Commission through the Post Office Savings Bank, would produce an annuity equal to seventy-five per cent. of the annual value of the weekly payments. A lump sum is, however, often arranged by mutual agreement between the parties, without reference to the Sheriff.

The Government has, however, laid down a scale of pensions for loss due to injury on active service, and

the percentages correspond roughly with those in use in civil practice in France and Germany. Under ordinary circumstances the maximum pension of a private was 27s. 6d. per week. This has now been increased to 40s. for single and 50s. for married men with further increases for children, and this is represented in the subjoined list by 100%. On the Continent a maximum of 2/3 of wages earned is allowed, and this, therefore represents 100%. Sometimes an additional sum is permitted on the Continent, and the British Government may allow a higher pension where the injury is such that an artificial limb usually employed for a more serious injury is required.

Loss of two or more limbs; an arm or leg and an eye; both hands or both feet; all fingers and thumbs; a hand and foot; total loss of sight; total paralysis; injuries resulting in man becoming bedridden; injuries to head causing permanent disabling effects or Jacksonian epilepsy; very severe facial disfigurement—all of those are entitled to 100%.

Disarticulation of right arm at shoulder 90 per cent. (80).

Disarticulation at hip 80 per cent. (85).

Disarticulation at left shoulder 80 per cent. (70).

Severe facial disfigurement or total loss of speech 80 per cent.

Short thigh amputation 70 per cent. (80).

Amputation of right arm above or at elbow 70 per cent. (80).

Total Deafness 70 per cent.

Long thigh amputation 60 per cent. (70).

Disarticulation at knee 60 per cent. (65).

Amputation of left arm above or at elbow 60 per cent. (65).

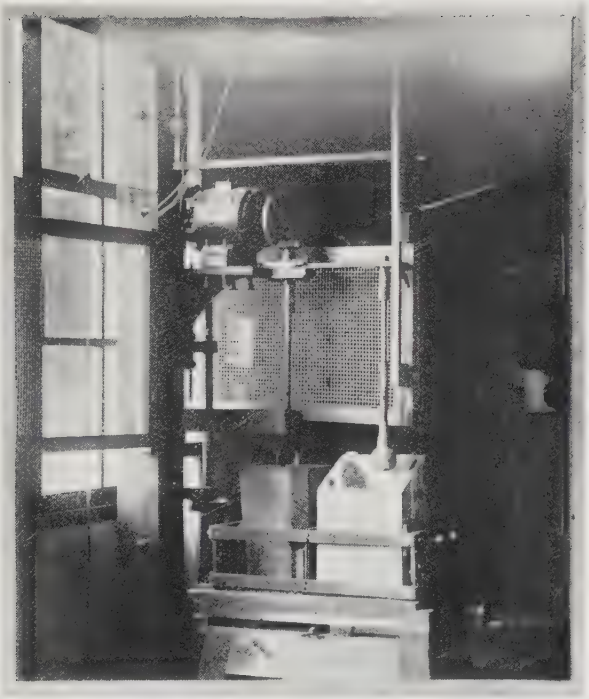
Amputation of right arm below elbow 60 per cent. (80).

Amputation of leg below knee, or of foot (Chopart or Syme) 50 per cent. (65).

Amputation of left arm below elbow 50 per cent. (65).

Loss of sight of one eye 50 per cent. (40).

PLATE XLIII.



Author's machine for automatically and rapidly cutting out a perfectly fitting wooden bucket from a plaster mould of stump.

Below is a strong table moved by screws in any desired direction, on which are clamped the mould (right) and block of wood for bucket (left). Above the mould is seen a "feeler" which dips into and presses against the side of the mould, thereby limiting the movements of the table, while above the block of wood is the revolving cutter.

The bucket can be made tight or easy by varying relative size of feeler and cutter.

Power is supplied by electro motor through gearing (6 in diagram).

Loss of (*a*) thumb or (*b*) of four fingers of right hand 40 per cent. (*a*, 30 *b*, 60).

Loss of (*a*) thumb or (*b*) of four fingers of left hand 30 per cent. (*a* 20, *b* 50).

Loss of three fingers of right hand 30 per cent. (33⅓ if index finger included.) (50).

Loss of two fingers of either hand 20 per cent. (33⅓ for fourth or fifth fingers of right hand).

It is presumed that the patient is right-handed. If left-handed, the percentages given for right arm apply to left. The lower limbs are of equal value.

The figures given in brackets refer to Continental percentages. It will be noticed that on the whole they are rather higher, except in the case of disarticulation at the shoulder, and loss of one eye.

On the Continent little discrimination appears to be made between disarticulation at the shoulder and loss of the hand, practically the same percentage being quoted for each. While a most useful limb is provided by a good below-elbow amputation, perhaps the British scale assesses the loss of the hand at too low a rate.

It will also be noticed that we attach greater importance to the thumb than Continental assessors, and less value to the fingers, particularly the index.

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